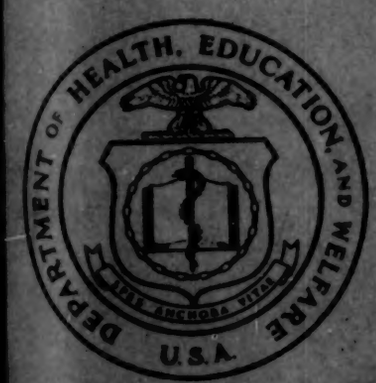
Volume I, No. 4

PB 161371-4

RADIOLOGICAL HEALTH DATA

QUARTERLY REPORT

JULY 1960



U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service

Distributed by U.S. Department of Commerce, Office of Technical Services, Washington 25, D.C.,
price 50 cents single issue, $3 for six months subscription.

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JULY 1960

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

Public Health Service

Division of Radiological Health

PREFACE

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned, among other things, primary responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels. Within the Department this responsibility has been delegated to the Division of Radiological Health, Public Health Service.

As a step in the discharge of this responsibility, the Public Health Service is publishing *Radiological Health Data.* This publication is issued monthly, with each third issue expanded somewhat into a quarterly report. This July 1960 issue is the first quarterly report.

The monthly and quarterly reports are reviewed by a Board of Editorial Advisors with representatives from the following Federal agencies:

Department of Health, Education, and Welfare
Atomic Energy Commission
Department of Defense
Department of Commerce
Department of Agriculture

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U. S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE
Public Health Service
Washington 25, D. C.

FOR IMMEDIATE RELEASE
Wednesday, July 20, 1960

HEW-N67a

CORRECTION

Note to Correspondents: This release supersedes HEW-N67 which contained several errors in the data reported. The corrected text follows:

The Public Health Service today released the July issue of its new technical publication, "Radiological Health Data," which reports on radioactivity in milk, air, water, and other environmental factors in the United States.

Results of dietary studies conducted during 1958, 1959, and 1960 at the Public Health Service's Sanitary Engineering Center, Cincinnati, Ohio, are given in the July issue. Included are analyses of typical meals selected at the Sanitary Engineering Center which showed strontium 90 content ranging from an average of 1.2 micromicrocuries per meal for breakfast in January 1960 (eight samples) to an average of 7.7 micromicrocuries per meal for lunch in November 1959 (nine samples). The Public Health Service said these amounts of strontium 90 were well below its presently accepted guideline of a yearly average of 73 micromicrocuries of strontium 90 total daily intake in the diet of the average person and are not higher in Cincinnati than in other comparable cities throughout the country.

Presented in the July issue is the first set of data from a study of human bones collected from the St. Louis, Missouri, area, where the strontium 90 content of milk has been consistently higher than for most of the country.

(More)

According to the Public Health Service, the number of samples analyzed so far (57) is too small to permit drawing firm conclusions. The Service added, however, that the strontium 90 content of bones from this area does not vary markedly from that of previously reported samples collected in North America as a whole.

In addition to regularly reported monthly levels of strontium 90 in milk, the quarterly issue includes a summary of the yearly average, and maximum levels, for stations of the Public Health Service milk-monitoring system, dating from the inauguration of this program. In the period covered by this issue--February 1960--the measurements of strontium 90 in milk, in micromicrocuries per litre, ranged from 1.7 for Sacramento, California, to 19.3 for Atlanta, Georgia. The average for the preceding twelve months was 4.7 for Sacramento and 16.4 for Atlanta.

Another summary section in the July issue of "Radiological Health Data" shows graphically the concentrations of short- and long-lived radionuclides in milk during the same period.

Likewise, all data on radioactivity in air, collected by the 44 stations of the Public Health Service Radiation Surveillance Network, are summarized in the current issue.

Among these regularly reported data, including air data from the U. S. Naval Research Laboratory and the Atomic Energy Commission, no unusual levels of radiation were recorded, with the exception of transient increases in radioactivity in the air which persisted through March, due to the nuclear detonation in the Sahara on February 13, 1960.

Reproduced in this issue are two documents relating to Federal radiation protection criteria: the first report and recommendations to the President from

the Federal Radiation Council entitled "Radiation Protection Guidance for Federal Agencies," and a statement issued April 28, 1960, by Health, Education, and Welfare Secretary Arthur S. Flemming on the strontium 90 content of wheat and wheat products, in which a method of interpreting the health significance of radioactivity in foods was illustrated.

Also reproduced is the report of the Atomic Energy Commission to the Pennsylvania Department of Health on environmental radioactivity during 1959 at the Shippingport Atomic Power Station--this country's first large-scale nuclear reactor for the production of central-station electric power. The report concludes: "No significant contribution to either soil radioactivity levels or radioactive fallout levels from Shippingport was evident during 1959."

# # #

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RADIATION PROTECTION CRITERIA

During May and June there were two significant developments in the field of radiation protection criteria. One, the Special Radiation Subcommittee of the Joint (Congressional) Committee on Atomic Energy held a set of Hearings "Radiation Protection Criteria and Standards: Their Basis and Uses." A preprint of relevant materials was published in May 1960.* Publication of the testimony at the Hearings will be made in the fall of 1960.

Second, the first report of the Federal Radiation Council was released in the form of a memorandum to The President together with a 39 page document entitled Background Material for the Development of Radiation Protection Standards,** (May 13, 1960. The recommendations contained in the memorandum were approved by The President on May 13, 1960 and published in the Federal Register on May 18, 1960. The text of this memorandum is reproduced below.

The Radiation Protection Guides contained in the approved memorandum ". . . do not differ substantially from certain other recommendations such as those made by the National Committee on Radiation Protection and Measurement, the National Academy of Sciences, and the International Commission on Radiological Protection . . . ." These Guides are ". . . for the guidance of Federal agencies . . ." It is anticipated that appropriate Federal agencies will adopt standards and criteria within the framework of these broad guides.

Recognizing the need for further study of standards and criteria for internal emitters, the Federal Radiation Council has organized a full time temporary staff to prepare a report on this aspect of radiation criteria. Since this study has just been initiated, no time for completion has been set but it is anticipated that the report will be released before the end of the year.

During this period of intensive study of radiation protection criteria, the Department of Health, Education, and Welfare is using as a guideline in evaluating the strontium-90 (the principal isotope of concern) content of foodstuffs, a daily intake of 73 micromicrocuries for the general population. Individuals' diet may depart from this guideline by as much as three times over that for the general population value. Both guidelines refer to the strontium-90 content of the entire diet, averaged over a period of one year. They are not mandatory limits for regulatory action but rather guides in evaluating situations as they arise. This procedure of evaluation is illustrated in the press release of Arthur S. Flemming, Secretary of Health, Education, and Welfare, April 28, 1960 concerning the strontium-90 content of wheat. Secretary Flemming's statement is reproduced below.

FOR RELEASE IN A. M. PAPERS OF TUESDAY, MAY 17, 1960

A. Wayne Hawks, Acting Assistant Press Secretary

THE WHITE HOUSE

THE WHITE HOUSE TODAY MADE PUBLIC THE FOLLOWING MEMORANDUM TO THE PRESIDENT FROM THE CHAIRMAN OF THE FEDERAL RADIATION COUNCIL. THE PRESIDENT APPROVED RECOMMENDATIONS NUMBERED 1 THROUGH 7 OF THE MEMORANDUM FOR THE GUIDANCE OF FEDERAL AGENCIES.

MEMORANDUM FOR THE PRESIDENT

SUBJECT: Radiation Protection Guidance for Federal Agencies

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*Selected Materials on Radiation Protection Criteria and Standards: Their Basis and Uses. Joint Committee on Atomic Energy, Congress of the United States. May 1960. Government Printing Office, Washington, D. C. ($3.25)

**To be for sale by the Superintendent of Documents, Washington, D. C.

Pursuant to Executive Order 10831 and Public Law 86-373, the Federal Radiation Council has made a study of the hazards and use of radiation. We herewith transmit our first report to you concerning our findings and our recommendations for the guidance of Federal agencies in the conduct of their radiation protection activities.

It is the statutory responsibility of the Council to ". . . advise the President with respect to radiation matters, directly or indirectly affecting health, including guidance for all Federal agencies in the formulation of radiation standards and in the establishment and execution of programs of cooperation with States . . ."

Fundamentally, setting basic radiation protection standards involves passing judgment on the extent of the possible health hazard society is willing to accept in order to realize the known benefits of radiation. It involves inevitably a balancing between total health protection, which might require foregoing any activities increasing exposure to radiation, and the vigorous promotion of the use of radiation and atomic energy in order to achieve optimum benefits.

The Federal Radiation Council has reviewed available knowledge on radiation effects and consulted with scientists within and outside the Government. Each member has also examined the guidance recommended in this memorandum in light of his statutory responsibilities. Although the guidance does not cover all phases of radiation protection, such as internal emitters, we find that the guidance which we recommend that you provide for the use of Federal agencies gives appropriate consideration to the requirements of health protection and the beneficial uses of radiation and atomic energy. Our further findings and recommendations follow.

Discussion. The fundamental problem in establishing radiation protection guides is to allow as much of the beneficial uses of ionizing radiation as possible while assuring that man is not exposed to undue hazard. To get a true insight into the scope of the problem and the impact of the decisions involved, a review of the benefits and the hazards is necessary.

It is important in considering both the benefits and hazards of radiation to appreciate that man has existed throughout his history in a bath of natural radiation. This background radiation, which varies over the earth, provides a partial basis for understanding the effects of radiation on man and serves as an indicator of the ranges of radiation exposures within which the human population has developed and increased.

The benefits of ionizing radiation. Radiation properly controlled is a boon to mankind. It has been of inestimable value in the diagnosis and treatment of diseases. It can provide sources of energy greater than any the world has yet had available. In industry, it is used as a tool to measure thickness, quantity or quality, to discover hidden flaws, to trace liquid flow, and for other purposes. So many research uses for ionizing radiation have been found that scientists in many diverse fields now rank radiation with the microscope in value as a working tool.

The hazards of ionizing radiation. Ionizing radiation involves health hazards just as do many other useful tools. Scientific findings concerning the biological effects of radiation of most immediate interest to the establishment of radiation protection standards are the following:

1. Acute doses of radiation may produce immediate or delayed effects, or both.

2. As acute whole body doses increase above approximately 25 rems (units of radiation dose), immediately observable effects increase in severity with dose, beginning from barely detectable changes, to biological signs clearly indicating damage, to death at levels of a few hundred rems.

3. Delayed effects produced either by acute irradiation or by chronic irradiation are similar in kind, but the ability of the body to repair radiation damage is usually more effective in the case of chronic than acute irradiation.

4. The delayed effects from radiation are in general indistinguishable from familiar pathological conditions usually present in the population.

5. Delayed effects include genetic effects (effects transmitted to succeeding generations), increased incidence of tumors, lifespan shortening, and growth and development changes.

6. The child, the infant, and the unborn infant appear to be more sensitive to radiation than the adult.

7. The various organs of the body differ in their sensitivity to radiation.

8. Although ionizing radiation can induce genetic and somatic effects (effects on the individual during his lifetime other than genetic effects), the evidence at the present time is insufficient to justify precise conclusions on the nature of the dose-effect relationship at low doses and dose rates. Moreover, the evidence is insufficient to prove either the hypothesis of a "damage threshold" (a point below which no damage occurs) or the hypothesis of "no threshold" in man at low doses.

9. If one assumes a direct linear relation between biological effect and the amount of dose, it then becomes possible to relate very low dose to an assumed biological effect even though it is not detectable. It is generally agreed that the effect that may actually occur will not exceed the amount predicted by this assumption.

Basic biological assumptions. There are insufficient data to provide a firm basis for evaluating radiation effects for all types and levels of irradiation. There is particular uncertainty with respect to the biological effects at very low doses and low-dose rates. It is not prudent therefore to assume that there is a level of radiation exposure below which there is absolute certainty that no effect may occur. This consideration, in addition to the adoption of the conservative hypothesis of a linear relation between biological effect and the amount of dose, determines our basic approach to the formulation of radiation protection guides.

The lack of adequate scientific information makes it urgent that additional research be undertaken and new data developed to provide a firmer basis for evaluating biological risk. Appropriate member agencies of the Federal Radiation Council are sponsoring and encouraging research in these areas.

Recommendations. In view of the findings summarized above the following recommendations are made:

It is recommended that:

1. There should not be any man-made radiation exposure without the expectation of benefit resulting from such exposure. Activities resulting in man-made radiation exposure should be authorized for useful applications provided in recommendations set forth herein are followed.

It is recommended that:

2. The term "Radiation Protection Guide" be adopted for Federal use. This term is defined as the radiation dose which should not be exceeded without careful consideration of the reasons for doing so; every effort should be made to encourage the maintenance of radiation doses as far below this guide as practicable.

It is recommended that:

3. The following Radiation Protection Guides be adopted for normal peacetime operations:

TABLE I

Type of exposure	Condition	Dose (rem)
Radiation worker:		
(a) Whole body, head and trunk, active blood forming organs, gonads, or lens of eye.	Accumulated dose...	5 times the number of years beyond age 18.
	13 weeks.....	3.
(b) Skin of whole body and thyroid.....	Year.....	30.
	13 weeks.....	10.
(c) Hands and forearms, feet and ankles.....	Year.....	75.
	13 weeks.....	25.
(d) Bone.....	Body burden.....	0.1 microgram of radium-226 or its biological equivalent.
(c) Other organs.....	Year.....	15.
	13 weeks.....	5.
Population:		
(a) Individual.....	Year.....	0.5 (whole body).
(b) Average.....	30 year.....	5 (gonads).

The following points are made in relation to the Radiation Protection Guides herein provided:

(1) For the individual in the population, the basic Guide for annual whole body dose is 0.5 rem. This Guide applies when the individual whole body doses are known. As an operational technique, where the individual whole body doses are not known, a suitable sample of the exposed population should be developed whose protection guide for annual whole body dose will be 0.17 rem per capita per year. It is emphasized that this is an operational technique which should be modified to meet special situations.

(2) Considerations of population genetics impose a per capita dose limitation for the gonads of 5 rems in 30 years. The operational mechanism described above for the annual individual whole body dose of 0.5 rem is likely in the immediate future to assure that the gonadal exposure Guide (5 rem in 30 years) is not exceeded.

(3) These Guides do not differ substantially from certain other recommendations such as those made by the National Committee on Radiation Protection and Measurements, the National Academy of Sciences, and the International Commission on Radiological Protection.

(4) The term "maximum permissible dose" is used by the National Committee on Radiation Protection (NCRP) and the International Commission on Radiological Protection (ICRP). However, this term is often misunderstood. The words "maximum" and "permissible" both have unfortunate connotations not intended by either the NCRP or the ICRP.

(5) There can be no single permissible or acceptable level of exposure without regard to the reason for permitting the exposure. It should be general practice to reduce exposure to radiation, and positive effort should be carried out to fulfill the sense of these recommendations. It is basic that exposure to radiation should result from a real determination of its necessity.

(6) There can be different Radiation Protection Guides with different numerical values, depending upon the circumstances. The Guides herein recommended are appropriate for normal peacetime operations.

(7) These Guides are not intended to apply to radiation exposure resulting from natural background or the purposeful exposure of patients by practitioners of the healing arts.

(8) It is recognized that our present scientific knowledge does not provide a firm foundation within a factor of two or three for selection of any particular numerical value in preference to another value. It should be recognized that the Radiation Protection Guides recommended in this paper are well below the level where biological damage has been observed in humans.

It is recommended that:

4. Current protection guides used by the agencies be continued on an interim basis for organ doses to the population.

Recommendations are not made concerning the Radiation Protection Guides for individual organ doses to the population, other than the gonads. Unfortunately, the complexities of establishing guides applicable to radiation exposure of all body organs preclude the Council from making recommendations concerning them at this time. However, current protection guides used by the agencies appear appropriate on an interim basis.

It is recommended that:

5. The term "Radioactivity Concentration Guide" be adopted for Federal use. This term is defined as the concentration of radioactivity in the environment which is determined to result in whole body or organ doses equal to the Radiation Protection Guide.

Within this definition, Radioactivity Concentration Guides can be determined after the Radiation Protection Guides are decided upon. Any given Radioactivity Concentration Guide is applicable only for the circumstances under which the use of its corresponding Radiation Protection Guide is appropriate.

It is recommended that:

6. The Federal agencies, as an interim measure, use radioactivity concentration guides which are consistent with the recommended Radiation Protection Guides. Where no Radiation Protection Guides are provided, Federal agencies continue present practices.

No specific numerical recommendations for Radioactivity Concentration Guides are provided at this time. However, concentration guides now used by the agencies appear appropriate on an interim basis. Where appropriate radioactivity concentration guides are not available, and where Radiation Protection Guides for specific organs are provided herein, the latter Guides can be used by the Federal agencies as a starting point for the derivation of radioactivity concentration guides applicable to their particular problems. The Federal Radiation Council has also initiated action directed towards the development of additional Guides for radiation protection.

It is recommended that:

7. The Federal agencies apply these Radiation Protection Guides with judgment and discretion, to assure that reasonable probability is achieved in the attainment of the desired goal of protecting man from the undesirable effects of radiation. The Guides may be exceeded only after the Federal agency

having jurisdiction over the matter has carefully considered the reason for doing so in light of the recommendations in this paper.

The Radiation Protection Guides provide a general framework for the radiation protection requirements. It is expected that each Federal agency, by virtue of its immediate knowledge of its operating problems, will use these Guides as a basis upon which to develop detailed standards tailored to meet its particular requirements. The Council will follow the activities of the Federal agencies in this area and will promote the necessary coordination to achieve an effective Federal program.

If the foregoing recommendations are approved by you for the guidance of Federal agencies in the conduct of their radiation protection activities, it is further recommended that this memorandum be published in the FEDERAL REGISTER.

ARTHUR S. FLEMMING,
Chairman, Federal Radiation Council

The recommendations numbered "1" through "7" contained in the above memorandum are approved for the guidance of Federal agencies, and the memorandum shall be published in the FEDERAL REGISTER.

DWIGHT D. EISENHOWER

May 13, 1960.

STATEMENT*

By Arthur S. Flemming
Secretary of Health, Education, and Welfare

I have been provided with a copy of the regular quarterly statement of the Atomic Energy Commission on fallout, which is being released today. This statement contains information relating to the strontium 90 content of wheat and wheat products from the 1958 crop in 9 States.

At my request, the Public Health Service, the Food and Drug Administration, and the Federal Radiation Council have reviewed these data.

The advice given me by the Public Health Service and the Food and Drug Administration, which has been concurred in by the Federal Radiation Council and which I have accepted, is that the strontium 90 intake of the U. S. population from all dietary sources at the present time does not constitute a public health hazard warranting any regulatory action.

The data contained in the Atomic Energy Commission statement are summarized in the table below:

TABLE II.--WHEAT MILLING PRODUCTS--1958 CROP FROM 9 STATES (STRONTIUM 90 IN MICROMICROCURIES[1] PER KILOGRAM)

Reported by the Atomic Energy Commission, April 1960

Material	Strontium 90 micromicrocuries per kilogram		
	Low	High	Average
Wheat	21	133	62
Patent flour	3	42	12
1 and 2 clear flour	6	86	28
Germ	50	191	
Shorts	28	665	
Bran	52	675	231

[1]A curie is a measure of radioactivity equivalent to that produced by 1 gram of radium. A micromicrocurie is one millionth of a millionth of a curie.

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*Issued at Briefing Conference, Washington, D. C., Wednesday, April 27, 1960.

The Statement of the Atomic Energy Commission also shows that up to the present time analyses on the 1959 crop have been completed for whole wheat only. These analyses show results similar to those for the 1958 crop.

The conclusion that the present situation does not call for any regulatory action was based on the following considerations:

A. The guideline for average daily intake of strontium 90 used by this Department at present is 33 micromicrocuries per liter or kilogram of total dietary intake averaged over a period of one year. This value is derived from the recent interim recommendation of the National Committee on Radiation Protection and Measurements that the values suggested by the International Commission on Radiation Protection for planning purposes be accepted. Although this guideline was not developed to serve as a limit for regulatory purposes, it is a conservative basis for evaluating the significance of these data. For general populations the International Commission on Radiation Protection suggested 33 micromicrocuries per liter or kilogram based upon a 50-year exposure, but for operating purposes averaged over periods not to exceed one year. This value applies to all groups within the population. In considering the health effects of strontium 90 it is necessary to take into account the amounts ingested from all sources. The average weight of food and water ingested per day per individual in the U. S. is 2.2 kilograms. If all the food and water contained this concentration of 33 micromicrocuries per kilogram, then the daily intake of strontium 90 would be 73 micromicrocuries (2.2x33).

B. The following diet shows how the wheat data reported by the Atomic Energy Commission would be reflected in a typical adult diet. This diet is adapted from one that was presented by the Public Health Service at hearings of the Joint Committee on Atomic Energy last year. An estimated average daily consumption of 1.8 grams of bran, as estimated by the U. S. Department of Agriculture, was added to this diet (rounded in the table to 2.0 grams). The strontium 90 values for bran and flour products in this diet are the average values of the Atomic Energy Commission report. The strontium 90 values for other items of this diet are considered typical for a large metropolitan area.

TABLE III.—COMPARATIVE CONSUMPTION OF STRONTIUM 90 IN AN AVERAGE DIET OF 2,200 GRAMS PER DAY

(A gram is $\frac{1}{1,000}$ of a kilogram or $\frac{1}{28.35}$ of an ounce.)

	Strontium 90 content micromicrocuries per gram	Food consumption in grams per day	Strontium 90 micromicrocuries per day
Bran	.231	2.0	0.4
Flour products	.012	227	2.7
Foods other than milk, water, and wheat products	.004	971	3.9
Milk and milk products	.010	410	4.1
Water and other non-milk fluids	.001	590	1.0
Total	.....	2,200	12.1

C. The averages were used in the above table because the National Committee on Radiation Protection and the International Commission on Radiation Protection recommendations are for general population averages. It is, however, necessary to consider individual variations from the average involving the known deviations in concentrations of strontium 90 from the average and individual variations in dietary habits. In calculating the guidelines for specific averages the National Committee on Radiation Protection and the International Commission on Radiation Protection recommendations allow departures as much as 3 times such averages. In a given case this could be equivalent to an individual lifetime average of 220 micromicrocuries of strontium 90 per day.

I have had my staff calculate the strontium 90 content of various probable diets under the varying concentrations of strontium 90 reported by the Atomic Energy Commission. The conclusion was it would be highly improbable that any individual could attain an average of 73 micromicrocuries of strontium 90 per day for life, let alone the higher figure of 220 micromicrocuries.

* * * * * *

NOTE: The 9 States referred to in the opening paragraph of this statement are: Minnesota, North Dakota, Montana, Illinois, Kansas, Oklahoma, Texas, Michigan, and New York.

SECTION II

MILK

PUBLIC HEALTH SERVICE MILK MONITORING PROGRAM

The U. S. Public Health Service Milk Monitoring Network presently consists of 12 sampling stations. This will be expanded to about 60 stations by the summer of 1960.

The initial purpose of establishing this network was in keeping with the normal and continuing program of the Department of Health, Education, and Welfare to determine trends in our changing environment, including measurement of amounts of radioactivity in water, air, milk, and other foods. Milk was the food chosen for initial testing since it is among the most important elements of the diet and is constantly available at all seasons of the year and in all climates. A primary objective of the project was to develop and simplify methods of collection and radiochemical analysis of milk to make them more suitable for larger scale programs.

The selection of the present 12 sampling stations was based on the following criteria:

1. The milk represented in each sample was from a group of farms milking a total of at least 1,000 cows.

2. The number of individual farms was small enough so that collection of collateral field data from each farm was feasible.

3. The milk samples were from a supply that was part of a metropolitan milkshed.

4. The conditions under which the milk was received were such that each sample was representative of the same farms in the production area.

The Overton, Nevada and St. George, Utah milksheds do not fulfill the 1,000 cow minimum requirement but have been included since they are part of the monitoring program around the Nevada Test Site.

One gallon samples are collected once each month and forwarded by air parcel post to the Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio, for radionuclide analysis. It is estimated that these samples represent 2,000 gallon lots. The concentration of iodine-131, barium-140, and cesium-137 and naturally occurring potassium-40 are all currently being measured when present in the milk by gamma scintillation spectroscopy. Total strontium and strontium-90 are determined following radiochemical separations, and the strontium-90 is calculated by measuring the build-up of the daughter decay product, yttrium-90 (after about a two week wait) using a low background anticoincidence beta counter. The total radioactive strontium is counted in a shielded internal proportional counter with the strontium-89 calculated as the difference.

Publication of the data will normally require a period of about four months after collection due to shipment, processing, decay product build-up, compilation of the data, and inclusion with other radiation data in the monthly reports.

Concentrations of radionuclides in milk at all stations since mid-1957 are shown in figures 1 through 22.

A description of the program appears in "The Occurrence of Strontium-90, Iodine-131 and Other Radionuclides in Milk, May 1957 through April 1958," by J. E. Campbell, G. K. Murthy, A. S. Goldin, H. B. Robinson, C. P. Straub, F. J. Weber, and K. H. Lewis, American Journal of Public Health, Vol. 49, No. 2, Feb. 1959, American Public Health Association, reprinted by the Joint Committee on Atomic Energy Hearings on Fallout from Nuclear Weapons Tests, Vol. 1, May 1959.

Detailed technical descriptions of the methodology of analyses are listed below:

"Determination of I-131, Cs-137 and Ba-140 in Fluid Milk by Gamma Spectroscopy." By G. R. Hagee, G. R. Karches and A. S. Goldin, Public Health Service.

"A Method for the Rapid Ashing of Milk for Radionuclide Analysis," Journal of Dairy Science, 42-1288, Aug. 1959. By G. K. Murthy and J. E. Campbell.

"A Method for the Determination of Radionuclides in Milk Ash," Journal of Dairy Science, 14-1276, Aug. 1959. By G. K. Murthy, L. P. Jarnagin, and A. S. Goldin.

"A Method for the Elimination of Ashing in Strontium-90 Determination of Milk," Journal of Dairy Sciences, 43 (2) 151, Feb. 1960. By G. K. Murthy, J. E. Coakley and J. E. Campbell.

TABLE IV.--PUBLIC HEALTH SERVICE DATA ON RADIOACTIVITY IN MILK

FEBRUARY 1960

Data from one sampling point supplying the cities listed below.

Radioactivity in $\mu\mu$c/liter

Area	Calcium grams/liter		Iodine-131		Strontium-89		Strontium-90		Barium-140		Cesium-137	
	Feb.	Yearly average	Feb.	Yearly average	Feb.	Yearly average	Feb.	Yearly average	Feb.	Yearly average	Feb.	Yearly average
			(a)		(a)				(a)	(a)		
Atlanta, Ga.	1.11	1.17	0	2	0	35	19.3	16.4	0	0	65	82
Austin, Tex.	1.12	1.12	0	1	0	18	6.8	6.2	0	0	25	43
Chicago, Ill.	1.01	1.10	0	1	0	11	8.6	9.0	0	0	45	52
Cincinnati, Ohio	1.05	1.12	0	<1	0	14	11.4	12.7	0	0	40	46
Fargo, N. Dak. Moorhead, Minn.	Final Report on this Station, January 1960.											
New York, N. Y.	1.06	1.08	0	1	0	7	9.9	9.8	0	0	45	50
Overton, Nev.	1.08	1.08	0	0	0	2	5.6	3.4	0	0	30	29
Sacramento, Calif.	1.06	1.11	0	<1	0	12	1.7	4.7	0	0	10	39
Salt Lake City, Utah	1.09	1.11	0	2	0	7	6.2	7.1	0	0	40	44
Spokane, Wash.	1.14	1.16	0	3	0	18	12.8	13.1	0	0	55	66
St. George, Utah (b)	1.12	1.11	0	<1	0	4	2.2	4.3	0	0	20	28
St. Louis, Mo.	1.37	1.26	0	<1	0	49	18.8	22.4	0	<1	35	75

(a) Zero means below detectability.
(b) Average includes 11 months from start of the regular monthly collections.

"A Method for the Rapid Ashing of Milk for Radionuclide Analysis," Journal of Dairy Science, 42-1288, Aug. 1959. By G. K. Murthy and J. E. Campbell.

"A Method for the Determination of Radionuclides in Milk Ash," Journal of Dairy Science, 14-1276, Aug. 1959. By G. K. Murthy, L. P. Jarnagin, and A. S. Goldin.

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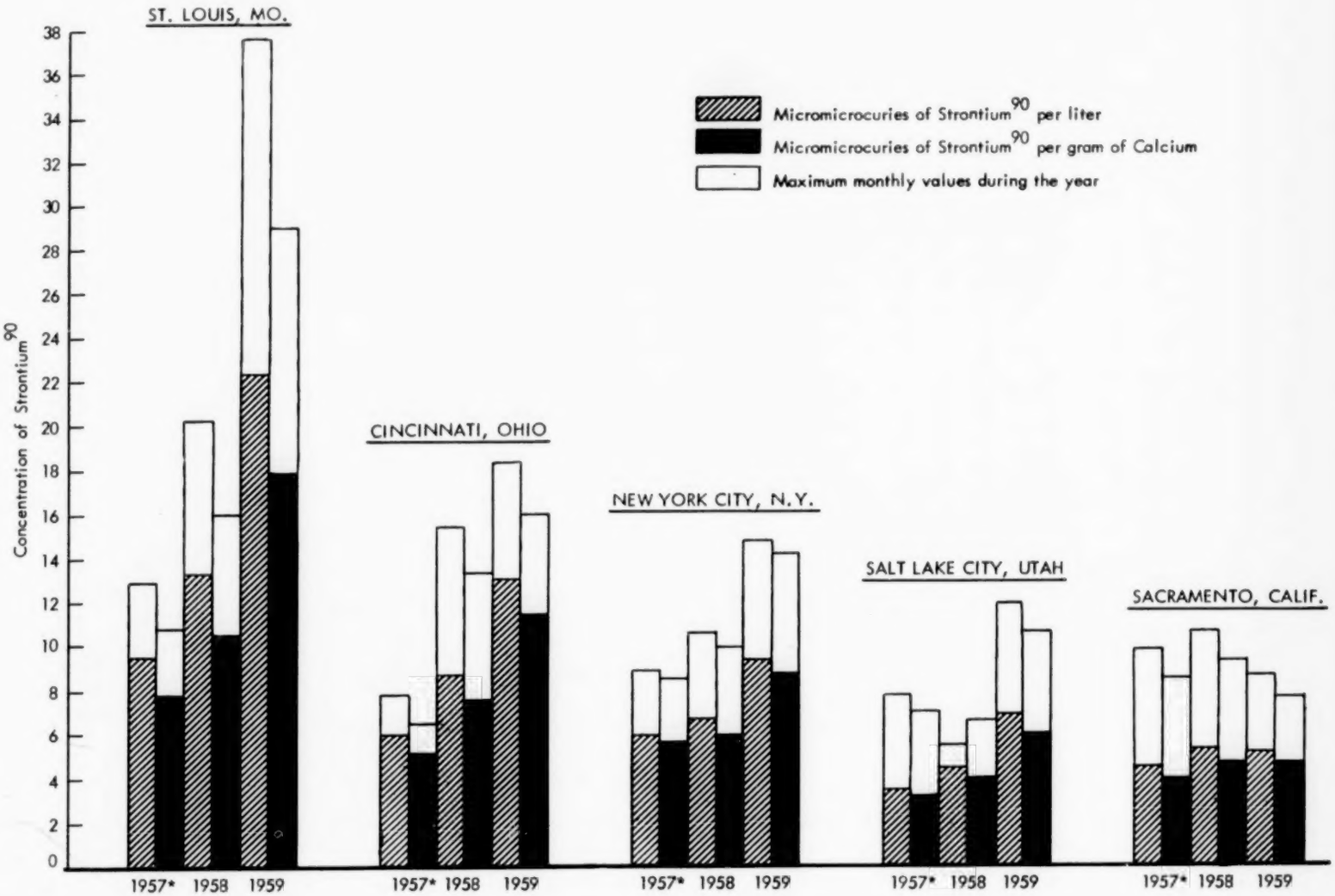
	Feb.	Yearly average	Feb.	Yearly average	Feb.	Yearly average	Feb.	Yearly average	Feb.	Yearly average	Feb.	Yearly average
			(a)		(a)				(a)	(a)		
Atlanta, Ga.	1.11	1.17	0	2	0	35	19.3	16.4	0	0	65	82
Austin, Tex.	1.12	1.12	0	1	0	18	6.8	6.2	0	0	25	43
Chicago, Ill.	1.01	1.10	0	1	0	11	8.6	9.0	0	0	45	52
Cincinnati, Ohio	1.05	1.12	0	<1	0	14	11.4	12.7	0	0	40	46
Fargo, N. Dak. Moorhead, Minn.	Final Report on this Station, January 1960.											
New York, N. Y.	1.06	1.08	0	1	0	7	9.9	9.8	0	0	45	50
Overton, Nev.	1.08	1.08	0	0	0	2	5.6	3.4	0	0	30	29
Sacramento, Calif.	1.06	1.11	0	<1	0	12	1.7	4.7	0	0	10	39
Salt Lake City, Utah	1.09	1.11	0	2	0	7	6.2	7.1	0	0	40	44
Spokane, Wash.	1.14	1.16	0	3	0	18	12.8	13.1	0	0	55	66
St. George, Utah (b)	1.12	1.11	0	<1	0	4	2.2	4.3	0	0	20	28
St. Louis, Mo.	1.37	1.26	0	<1	0	49	18.8	22.4	0	<1	35	75

(a) Zero means below detectability.
(b) Average includes 11 months from start of the regular monthly collections.

FIGURE 1

AVERAGE AND MAXIMUM ANNUAL CONCENTRATION OF STRONTIUM^{90} IN MILK
UNITED STATES, (1957 - 59)

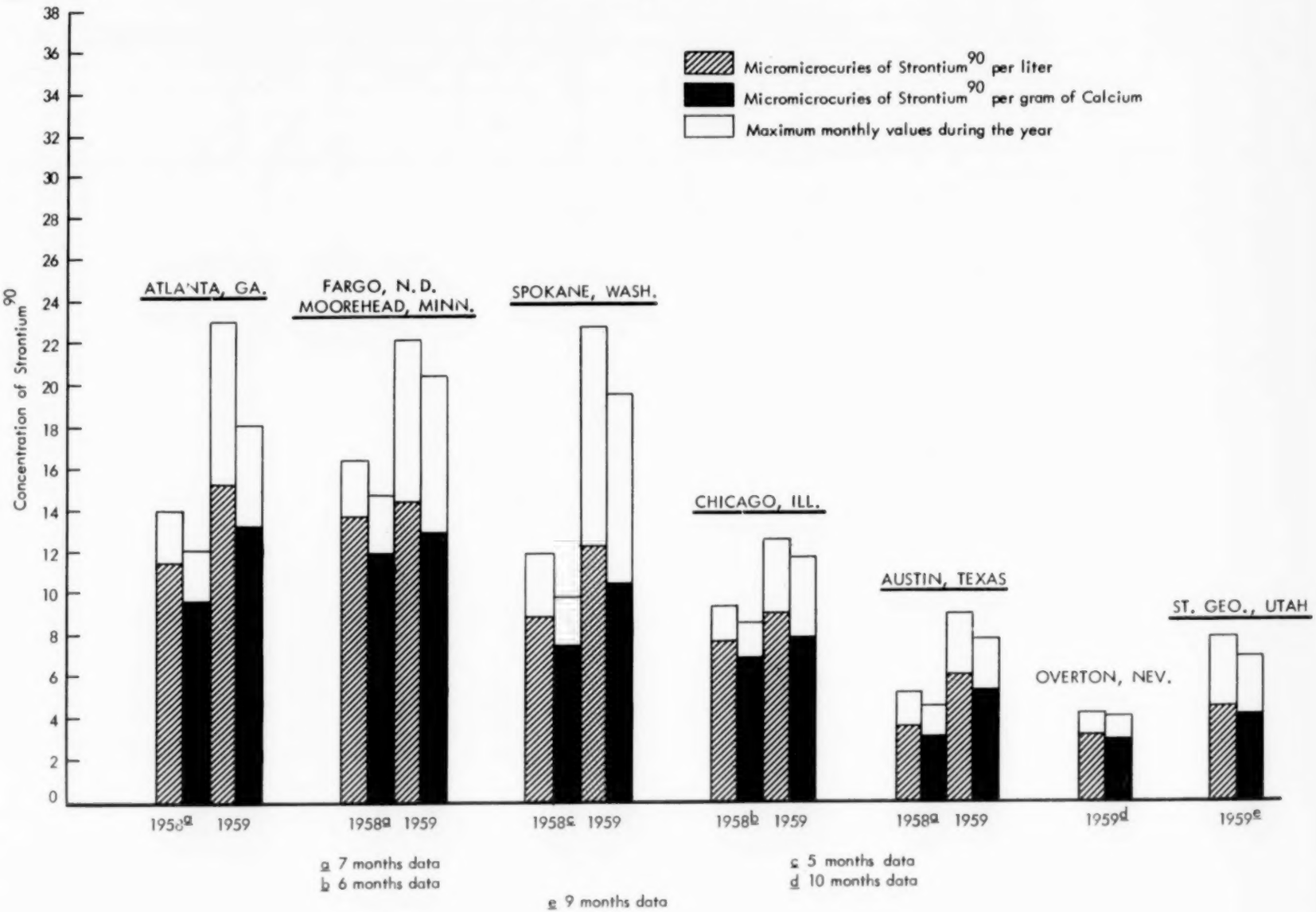


* 8 months data

FIGURE 2

AVERAGE AND MAXIMUM ANNUAL CONCENTRATION OF STRONTIUM^{90} IN MILK (Cont.)

UNITED STATES, (1957 - 59)



a 7 months data
b 6 months data
c 5 months data
d 10 months data
e 9 months data

FIGURE 3

SHORT LIVED RADIONUCLIDE CONCENTRATION IN MILK

ATLANTA, GEORGIA

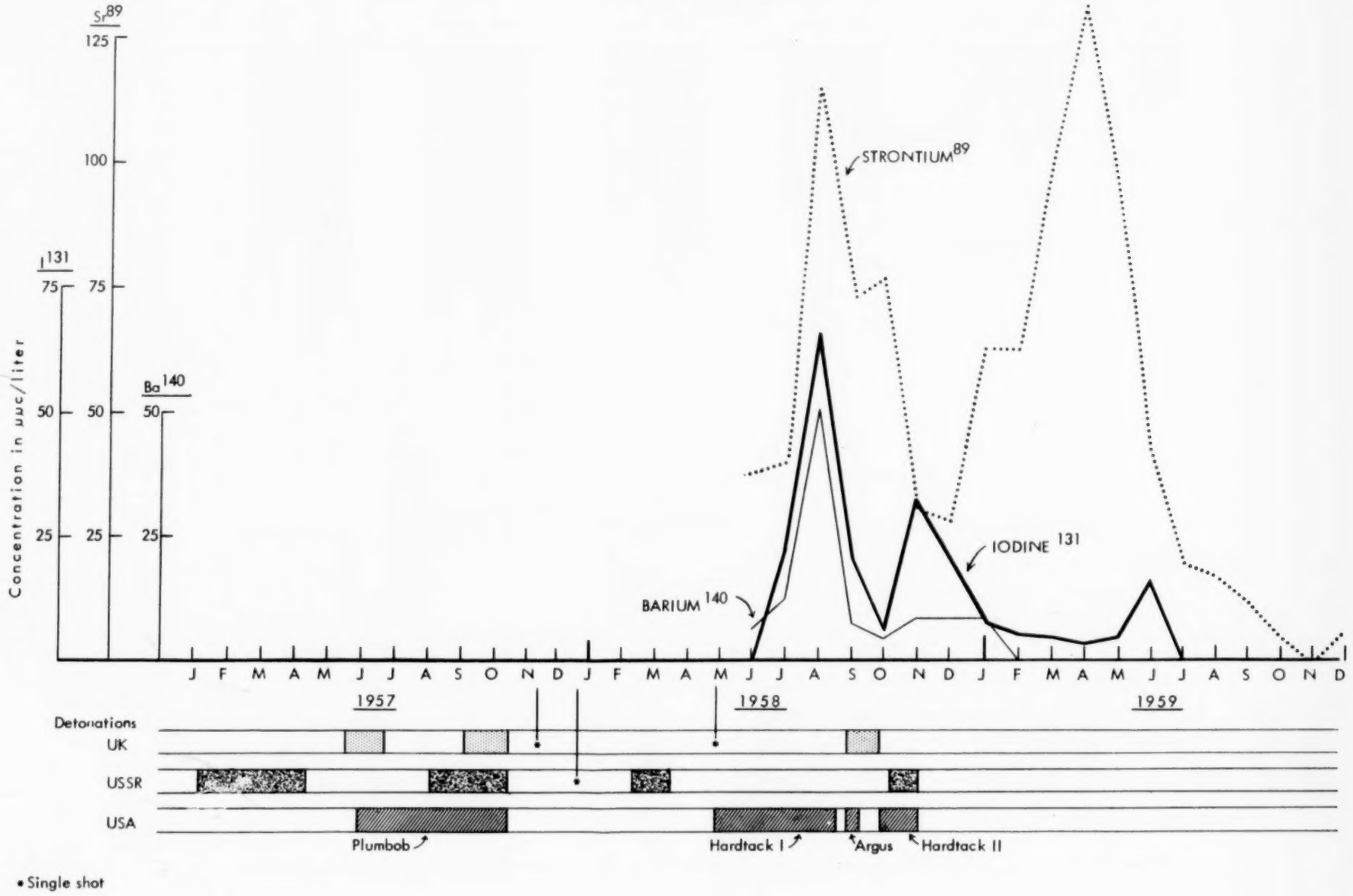


FIGURE 4

LONG LIVED RADIONUCLIDE CONCENTRATION IN MILK

ATLANTA, GEORGIA

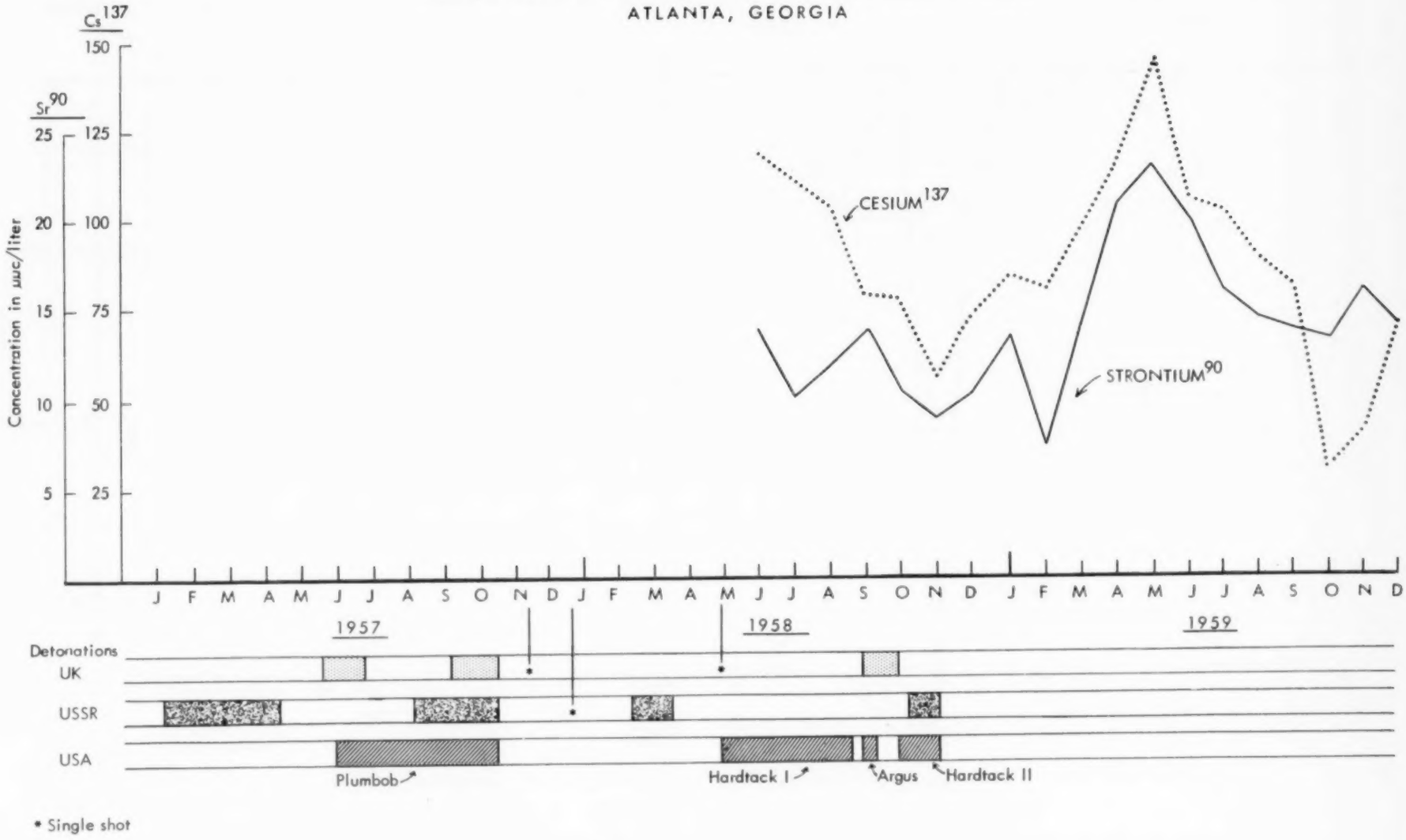
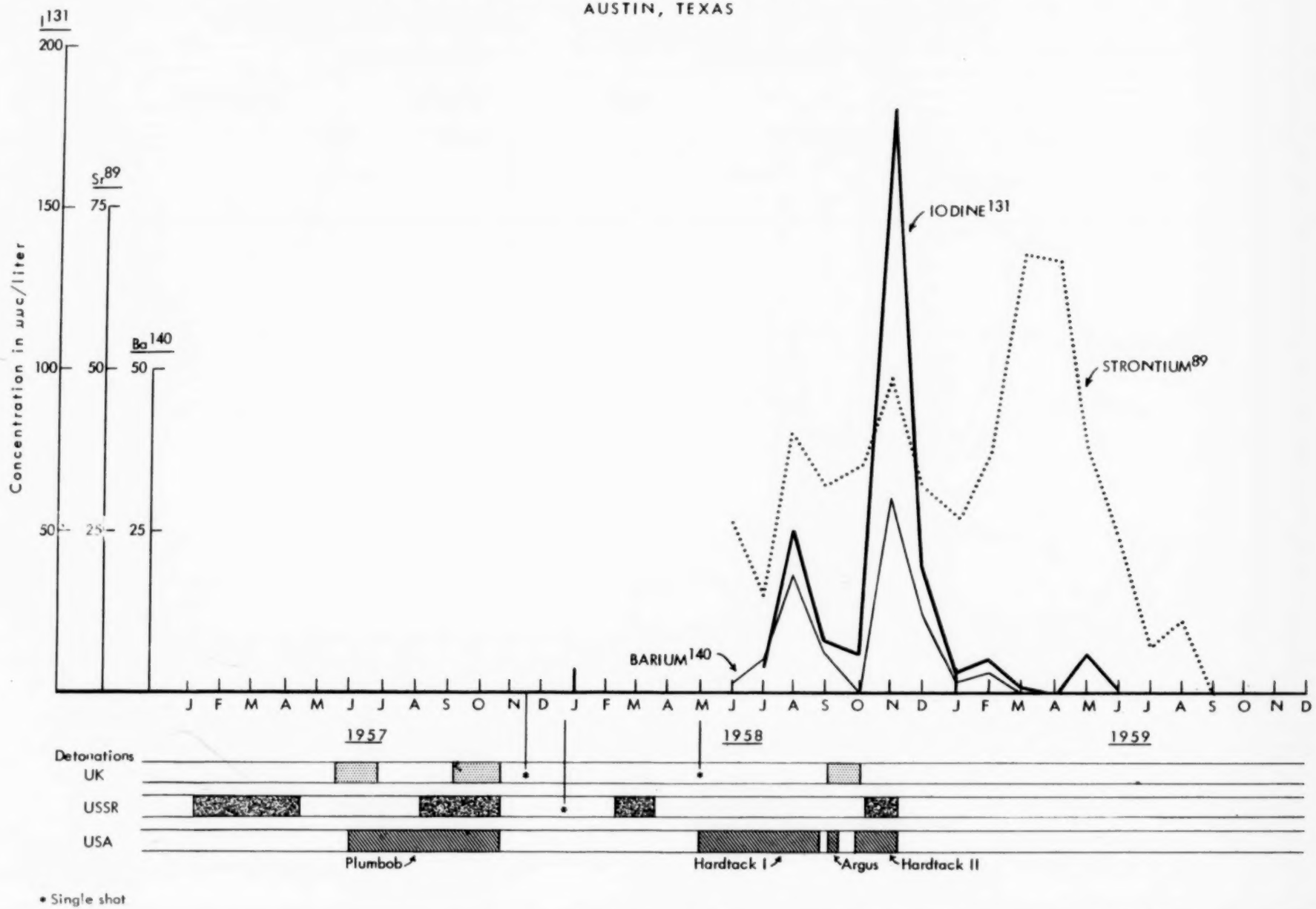


FIGURE 5

SHORT LIVED RADIONUCLIDE CONCENTRATION IN MILK

AUSTIN, TEXAS

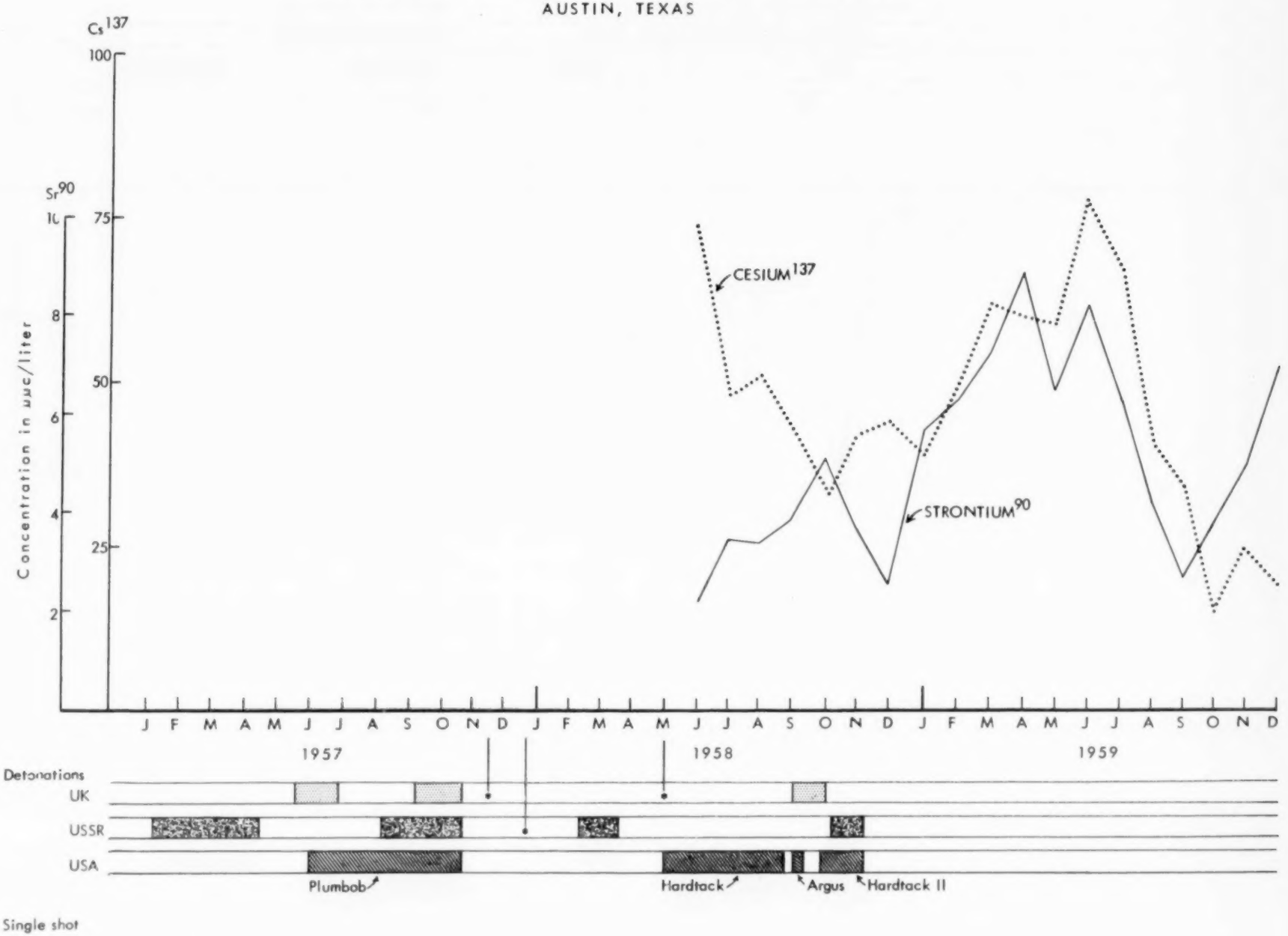


• Single shot

FIGURE 6

LONG LIVED RADIONUCLIDE CONCENTRATION IN MILK

AUSTIN, TEXAS



Single shot

FIGURE 7

SHORT LIVED RADIONUCLIDE CONCENTRATION IN MILK

CHICAGO, ILL.

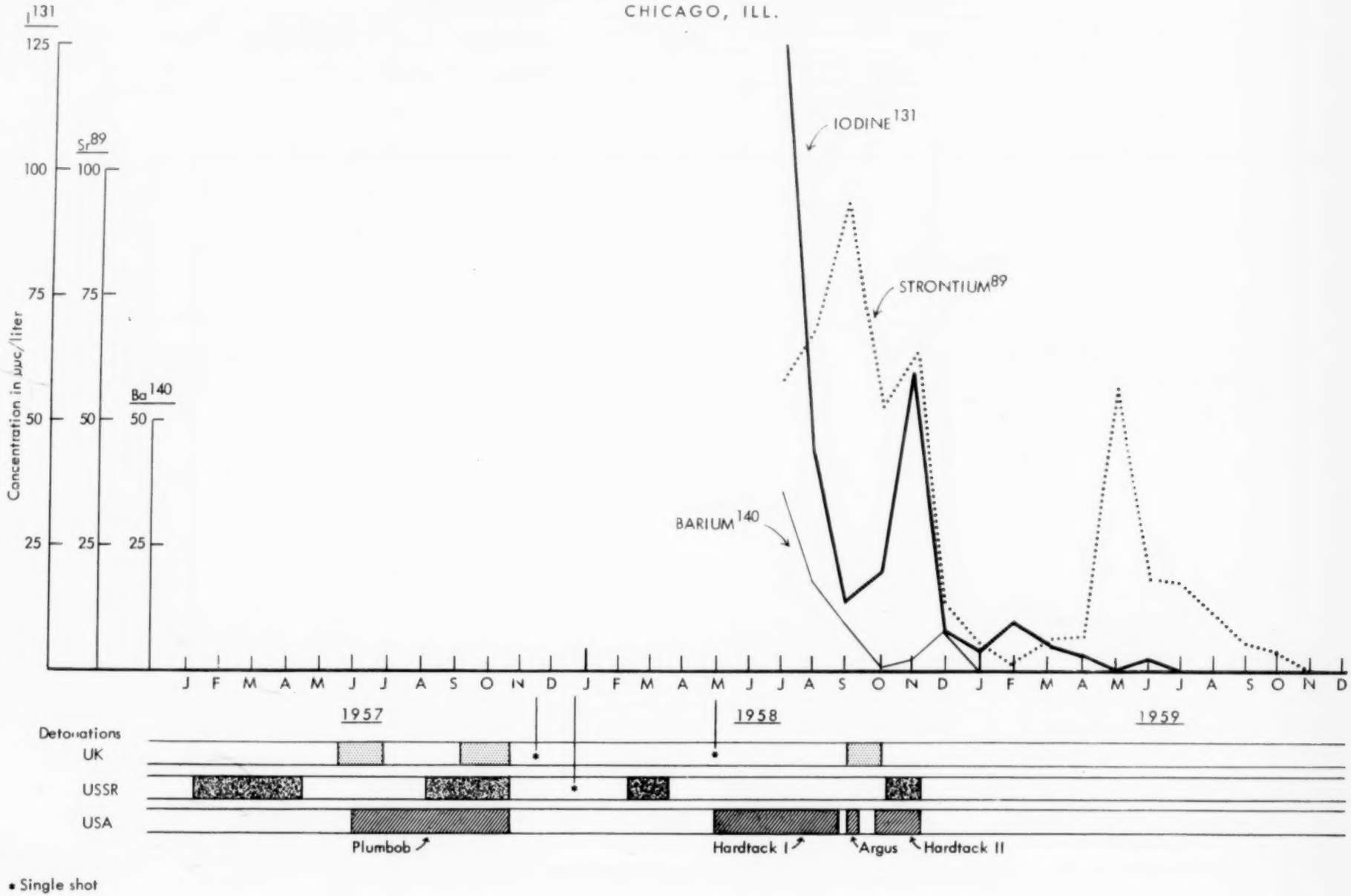


FIGURE 8

LONG LIVED RADIONUCLIDE CONCENTRATION IN MILK
CHICAGO, ILL.

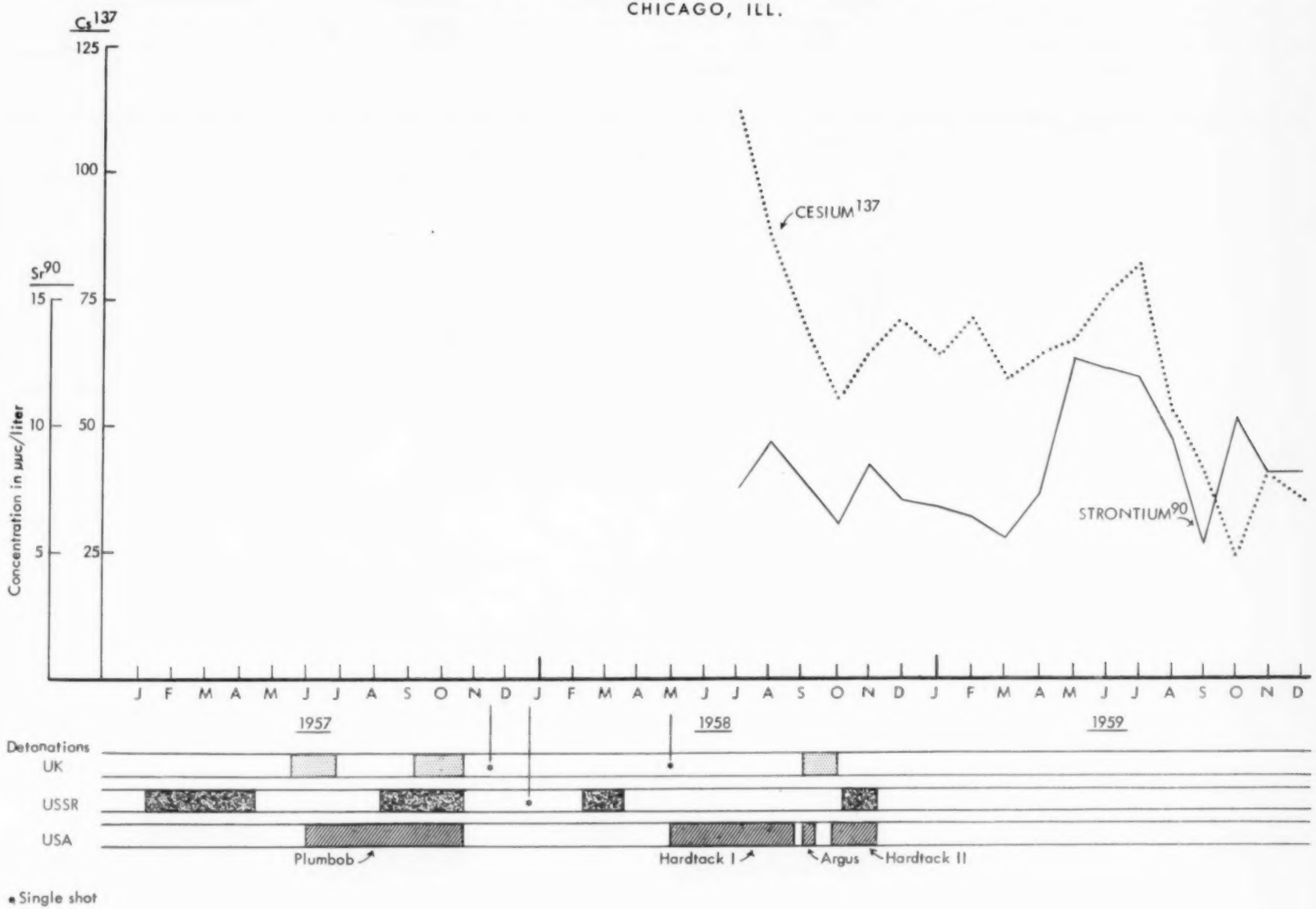
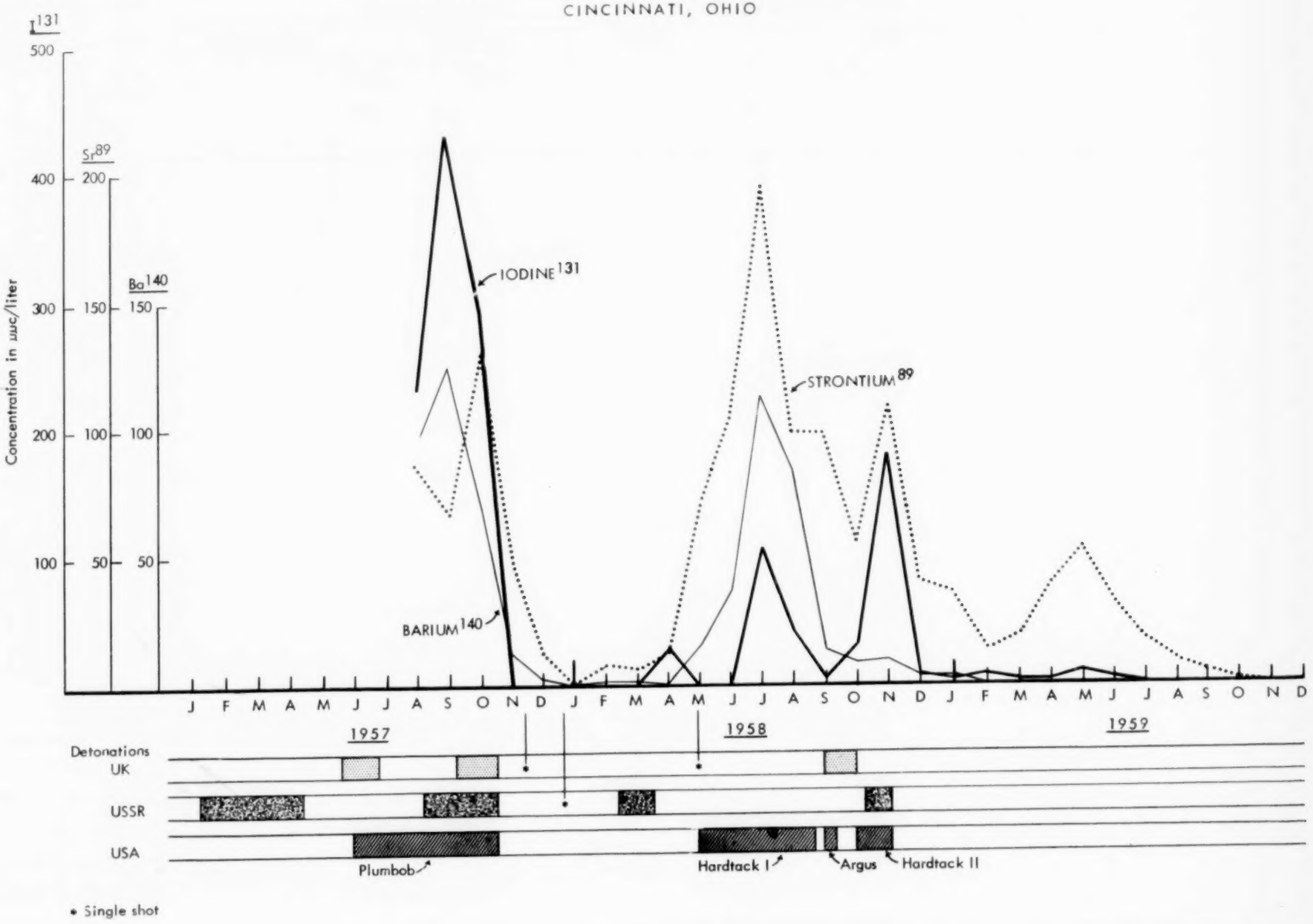


FIGURE 9

SHORT LIVED RADIONUCLIDE CONCENTRATION IN MILK

CINCINNATI, OHIO



• Single shot

FIGURE 10

LONG LIVED RADIONUCLIDE CONCENTRATION IN MILK
CINCINNATI, OHIO

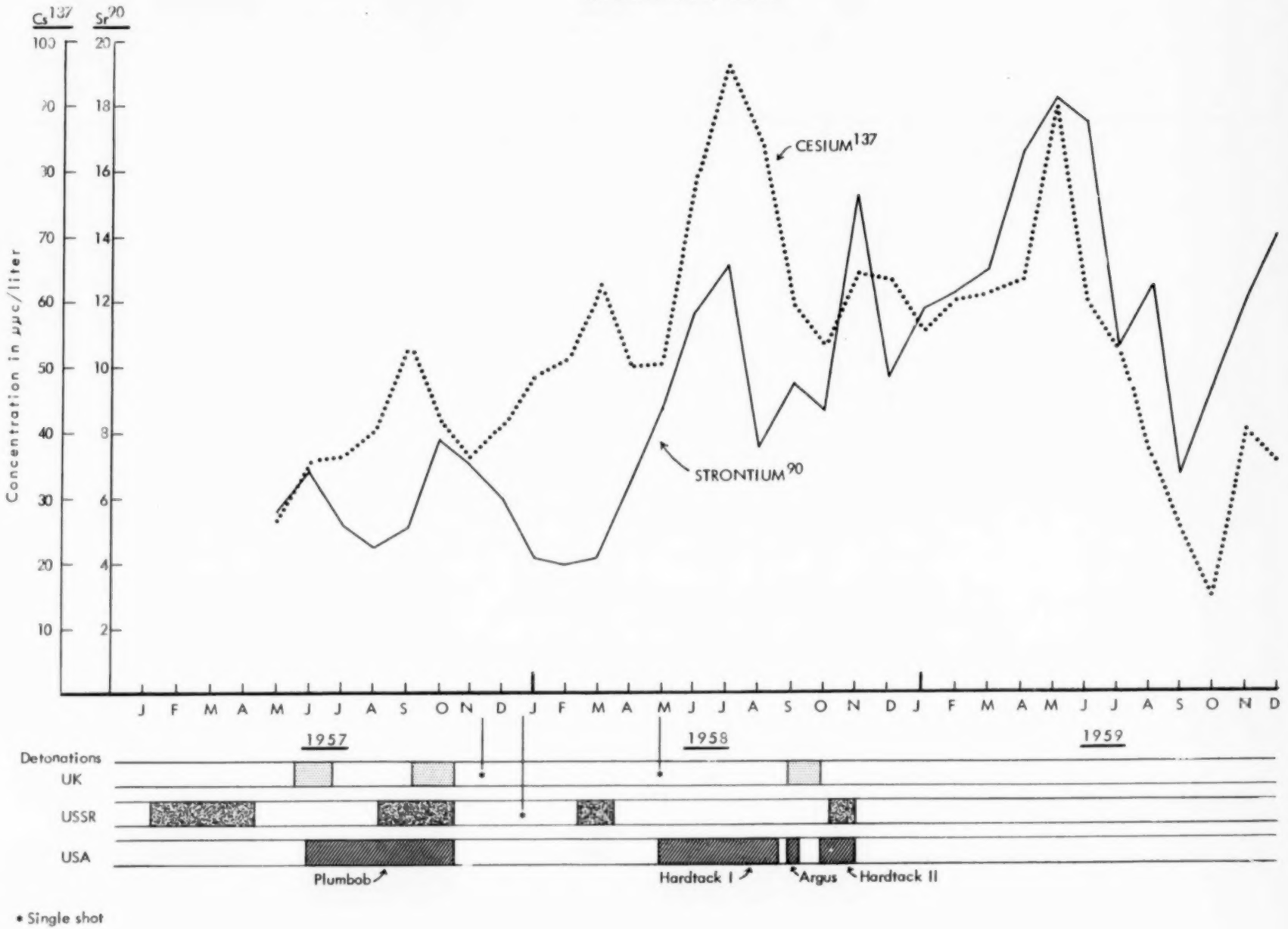
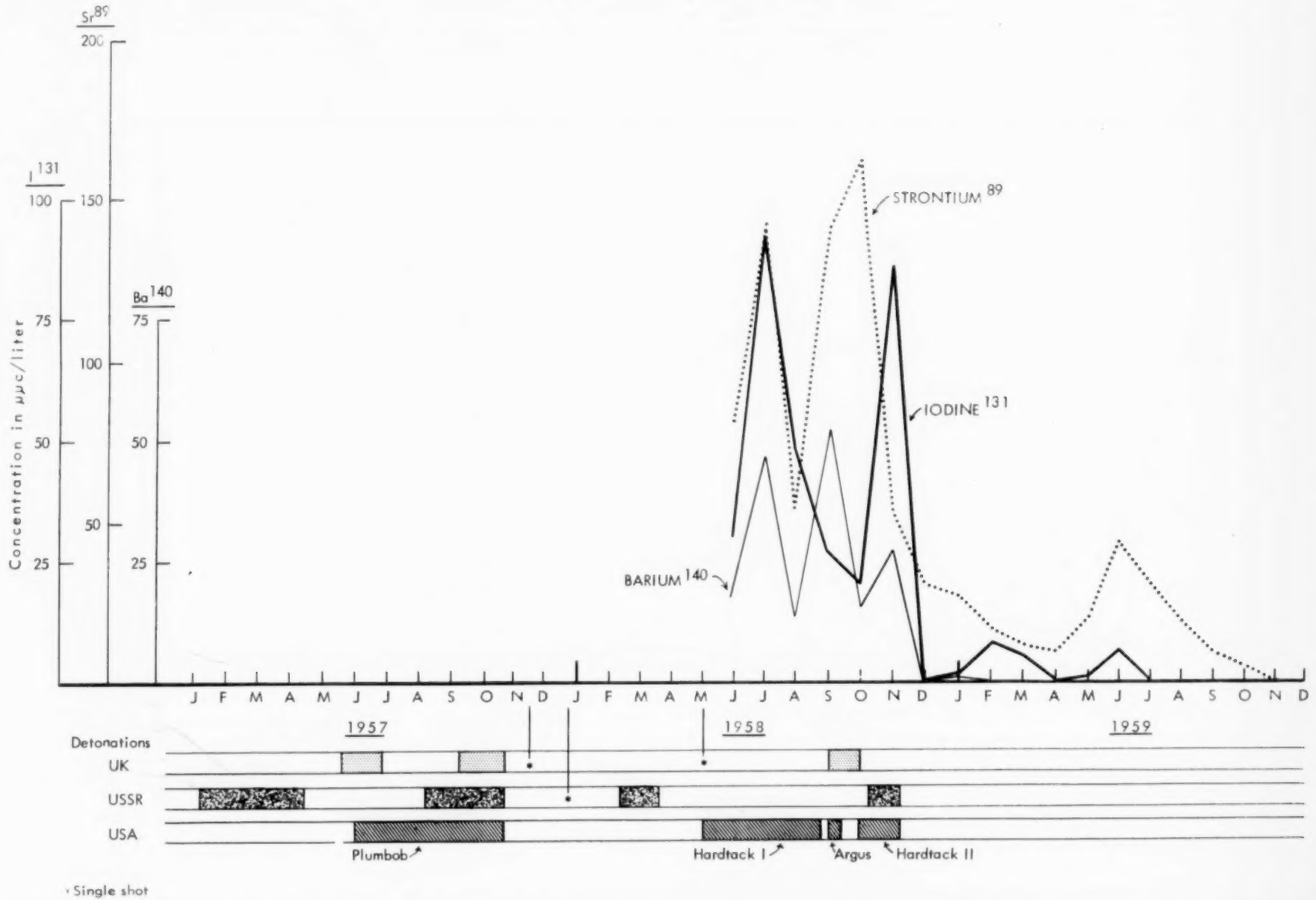


FIGURE 11

SHORT LIVED RADIONUCLIDE CONCENTRATION IN MILK

FARGO, N.D. - MOOREHEAD, MINN

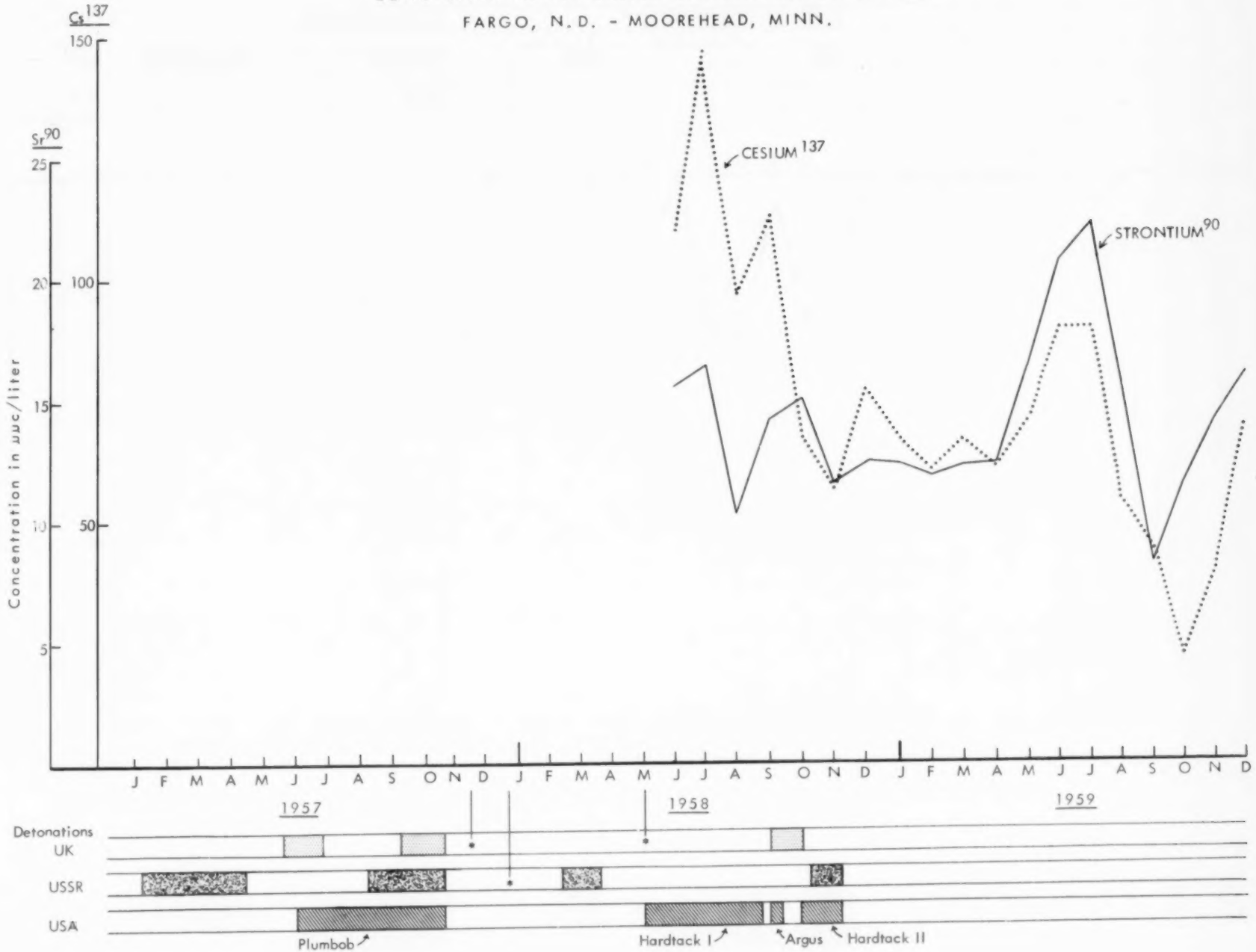


* Single shot

FIGURE 12

LONG LIVED RADIONUCLIDE CONCENTRATION IN MILK

FARGO, N. D. - MOOREHEAD, MINN.

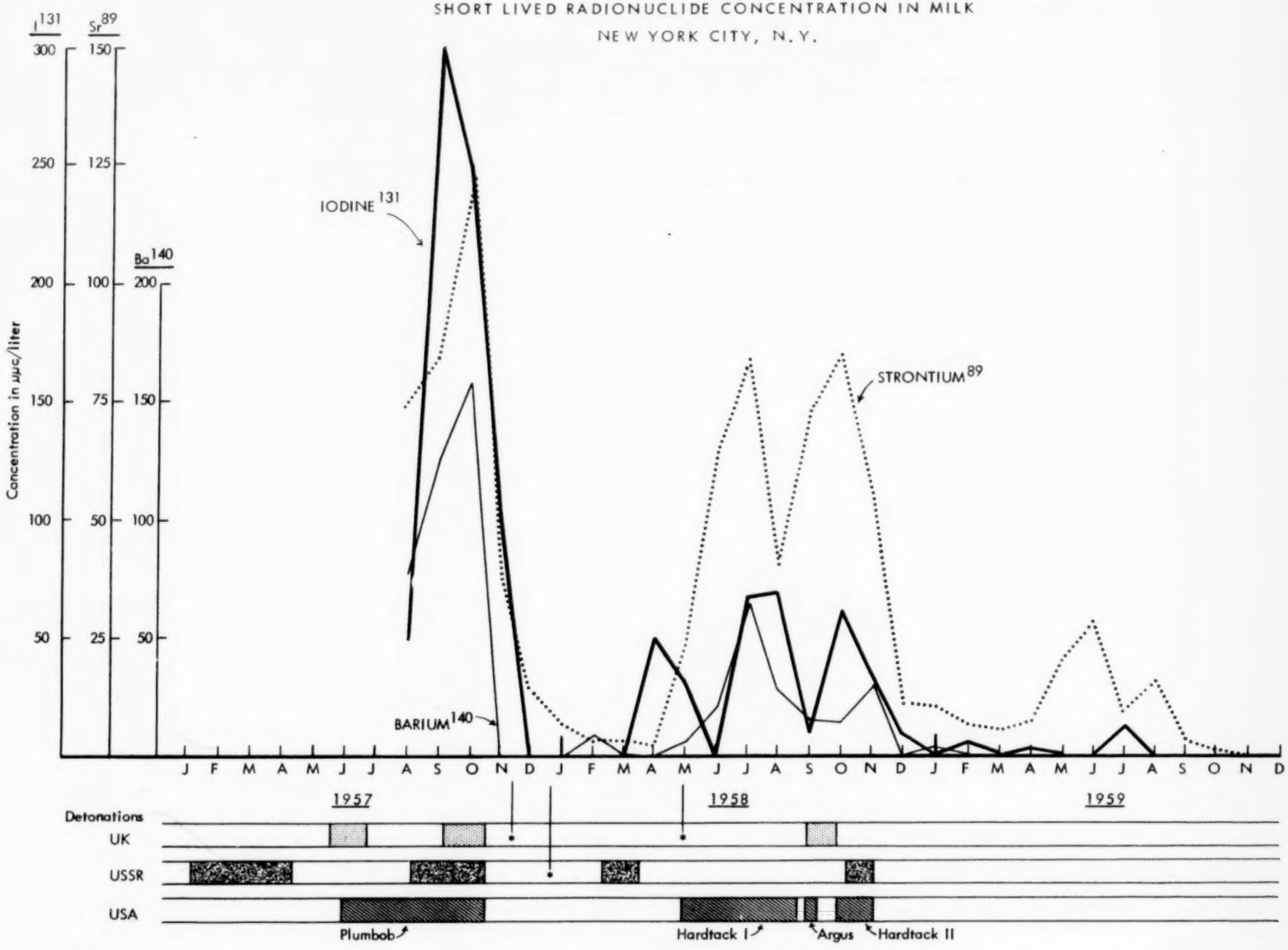


* Single shot

FIGURE 13

SHORT LIVED RADIONUCLIDE CONCENTRATION IN MILK

NEW YORK CITY, N.Y.

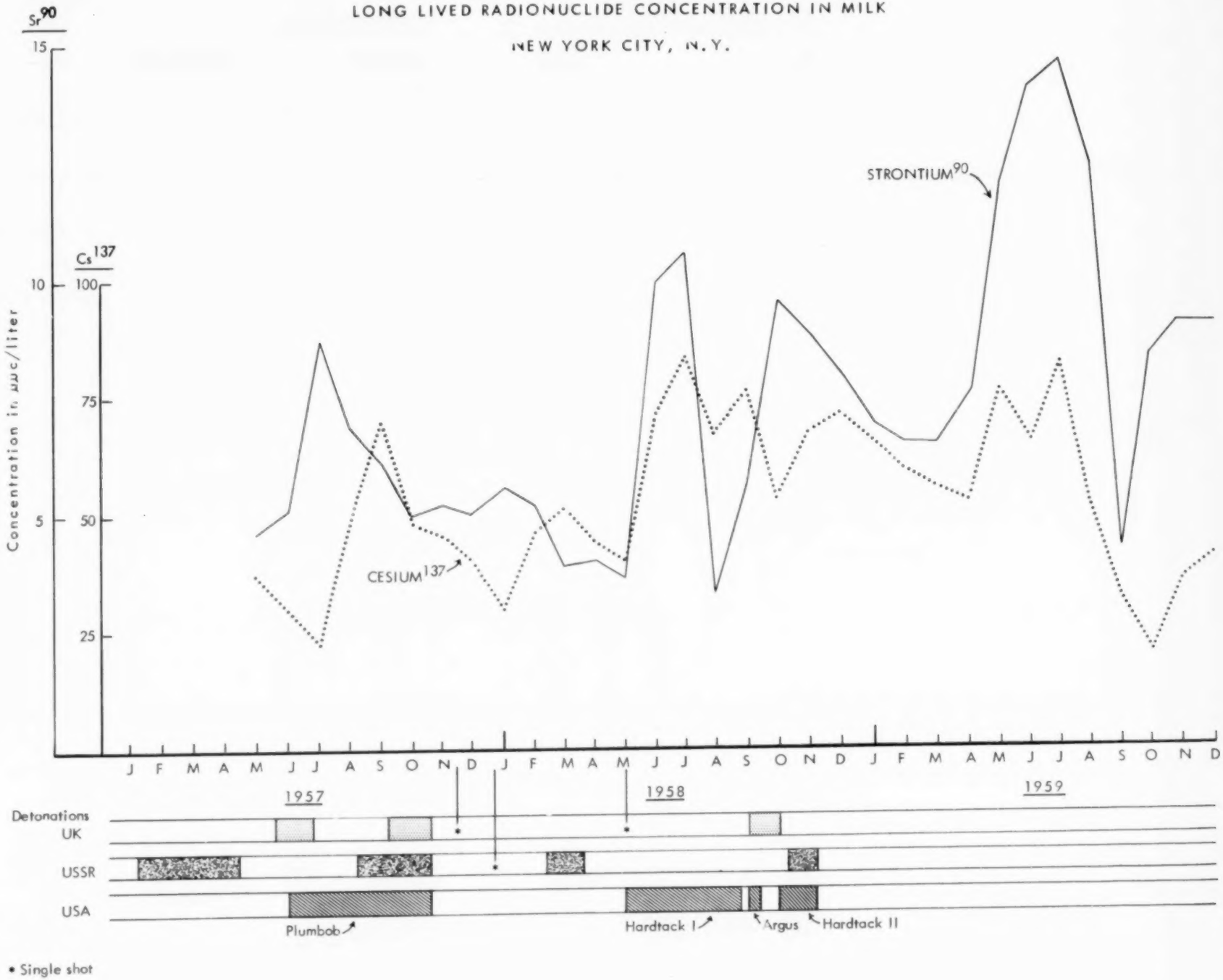


• Single shot

FIGURE 14

LONG LIVED RADIONUCLIDE CONCENTRATION IN MILK

NEW YORK CITY, N.Y.



• Single shot

FIGURE 15

SHORT LIVED RADIONUCLIDE CONCENTRATION IN MILK

SACRAMENTO, CALIF.

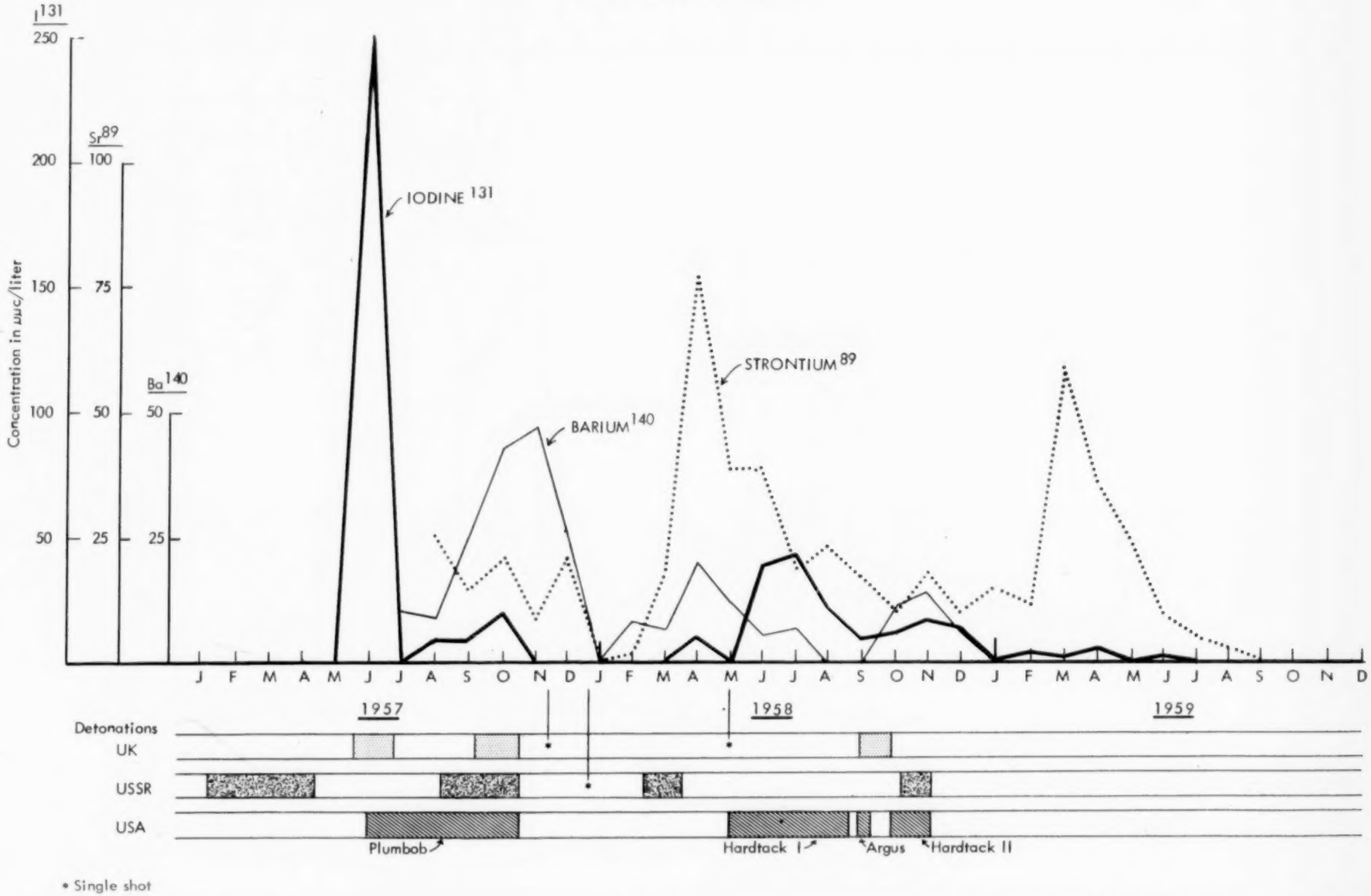
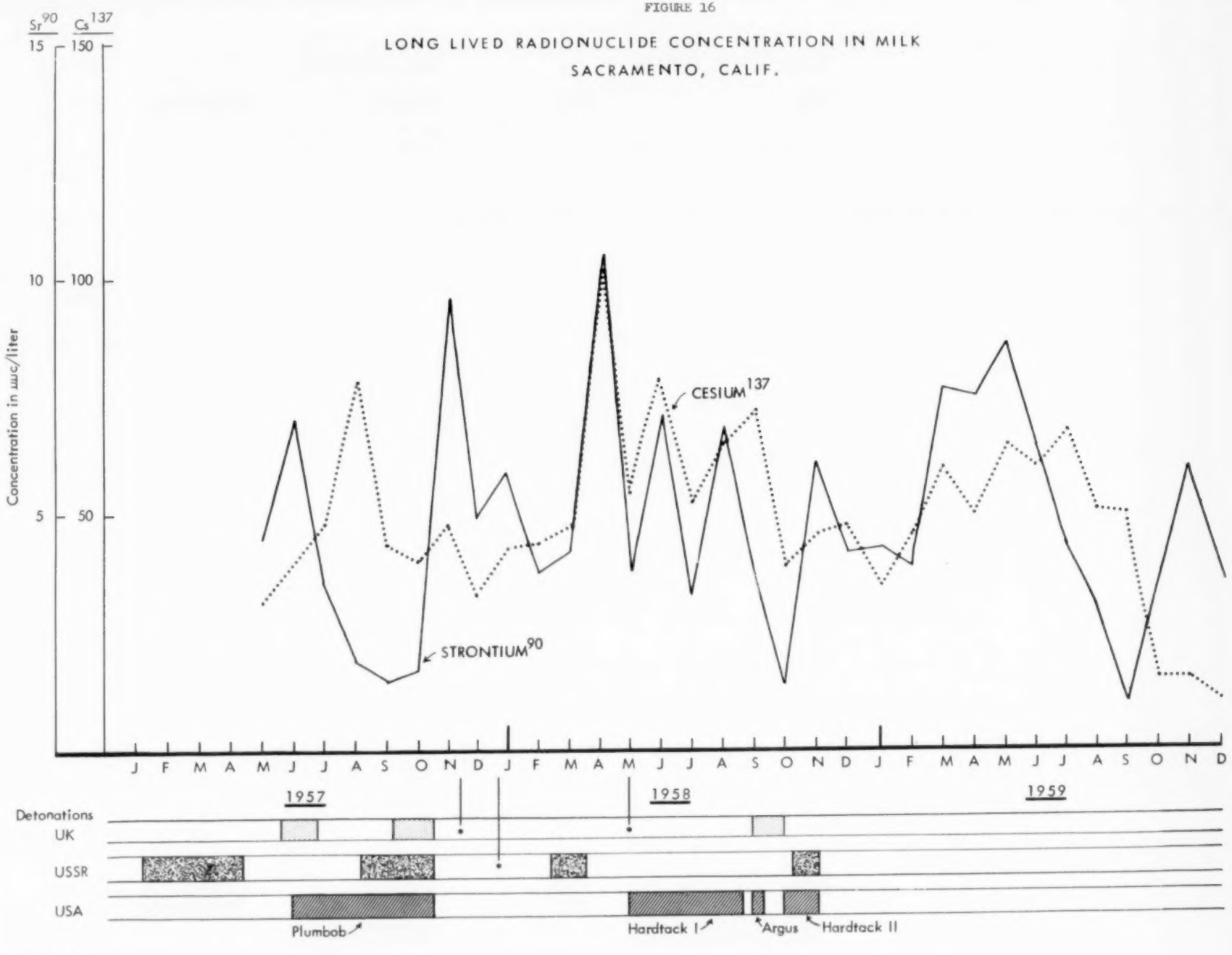


FIGURE 16

• Single shot

FIGURE 16

LONG LIVED RADIONUCLIDE CONCENTRATION IN MILK
SACRAMENTO, CALIF.



• Single shot

FIGURE 17

SHORT LIVED RADIONUCLIDE CONCENTRATION IN MILK

SALT LAKE CITY, UTAH

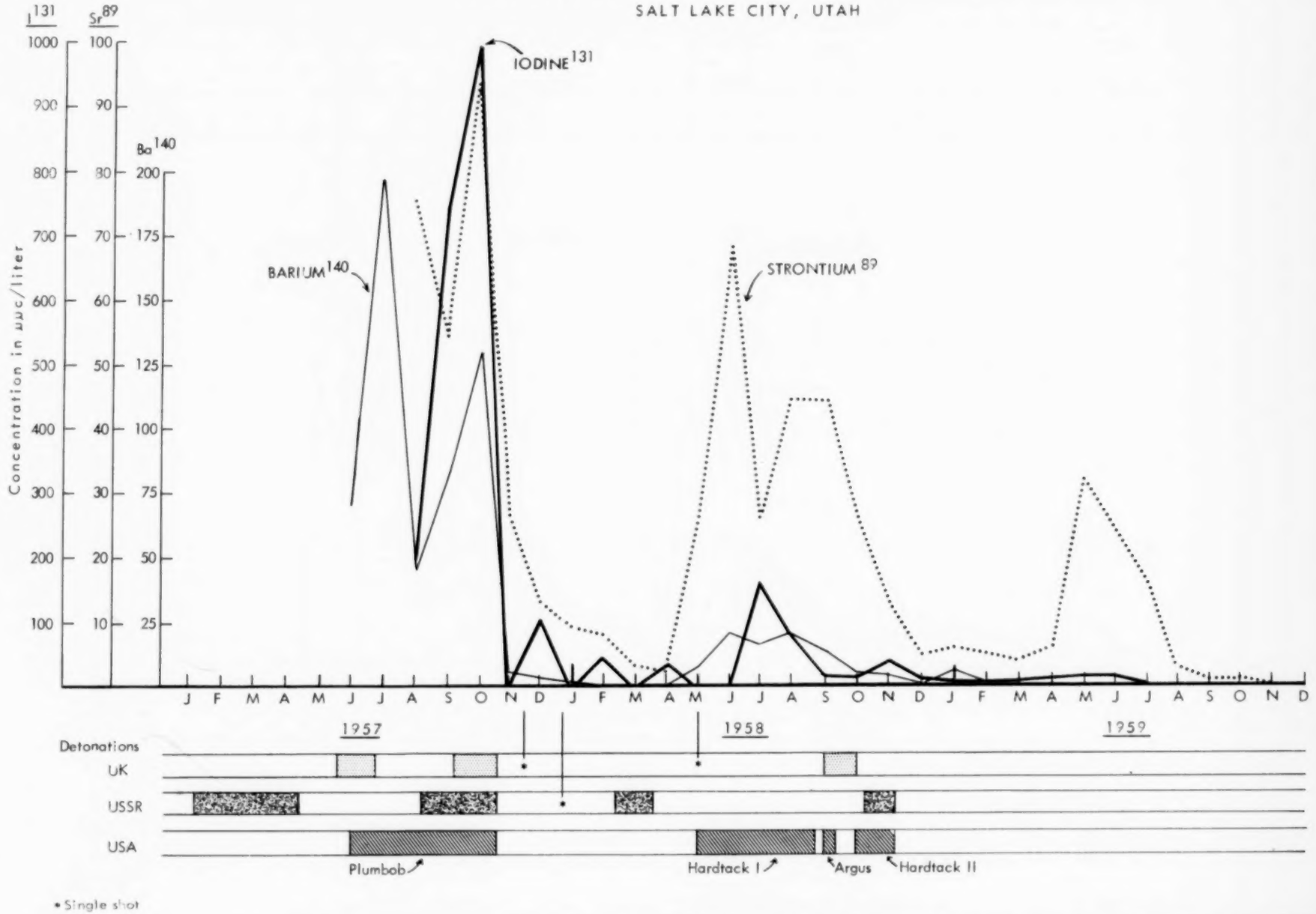


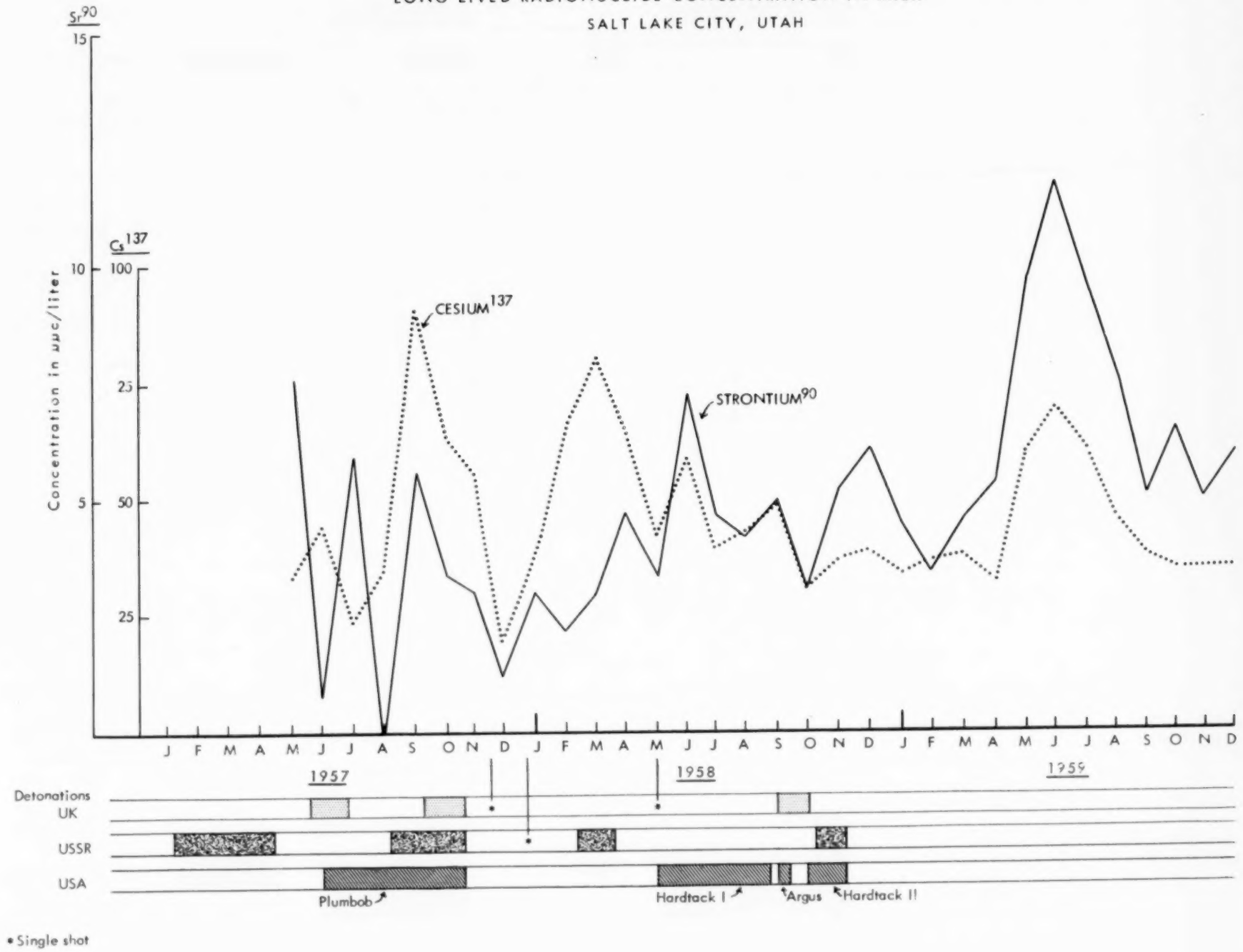
FIGURE 18

• Single shot

FIGURE 18

LONG LIVED RADIONUCLIDE CONCENTRATION IN MILK

SALT LAKE CITY, UTAH

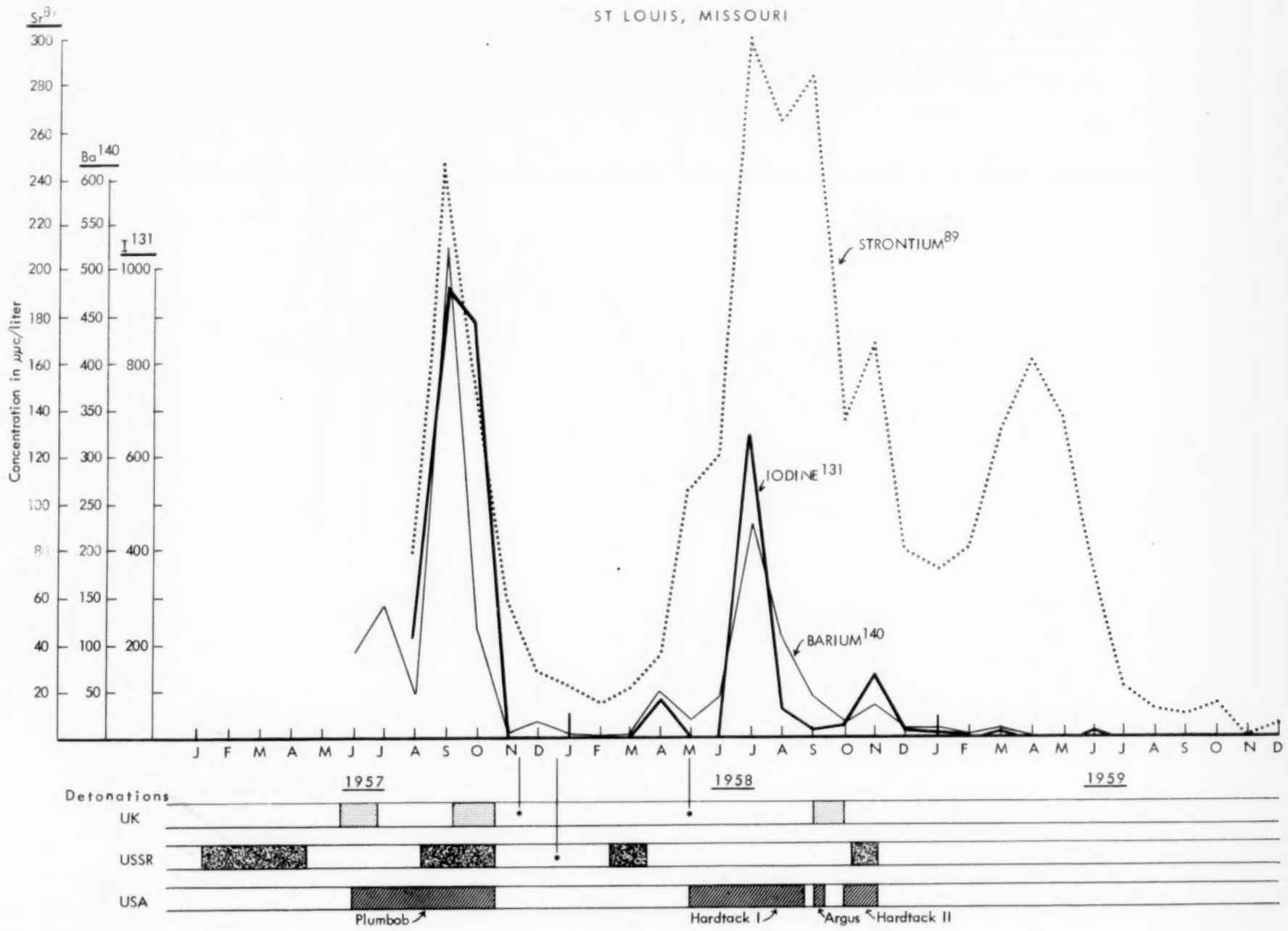


• Single shot

FIGURE 19

SHORT LIVED RADIONUCLIDE CONCENTRATION IN MILK

ST LOUIS, MISSOURI



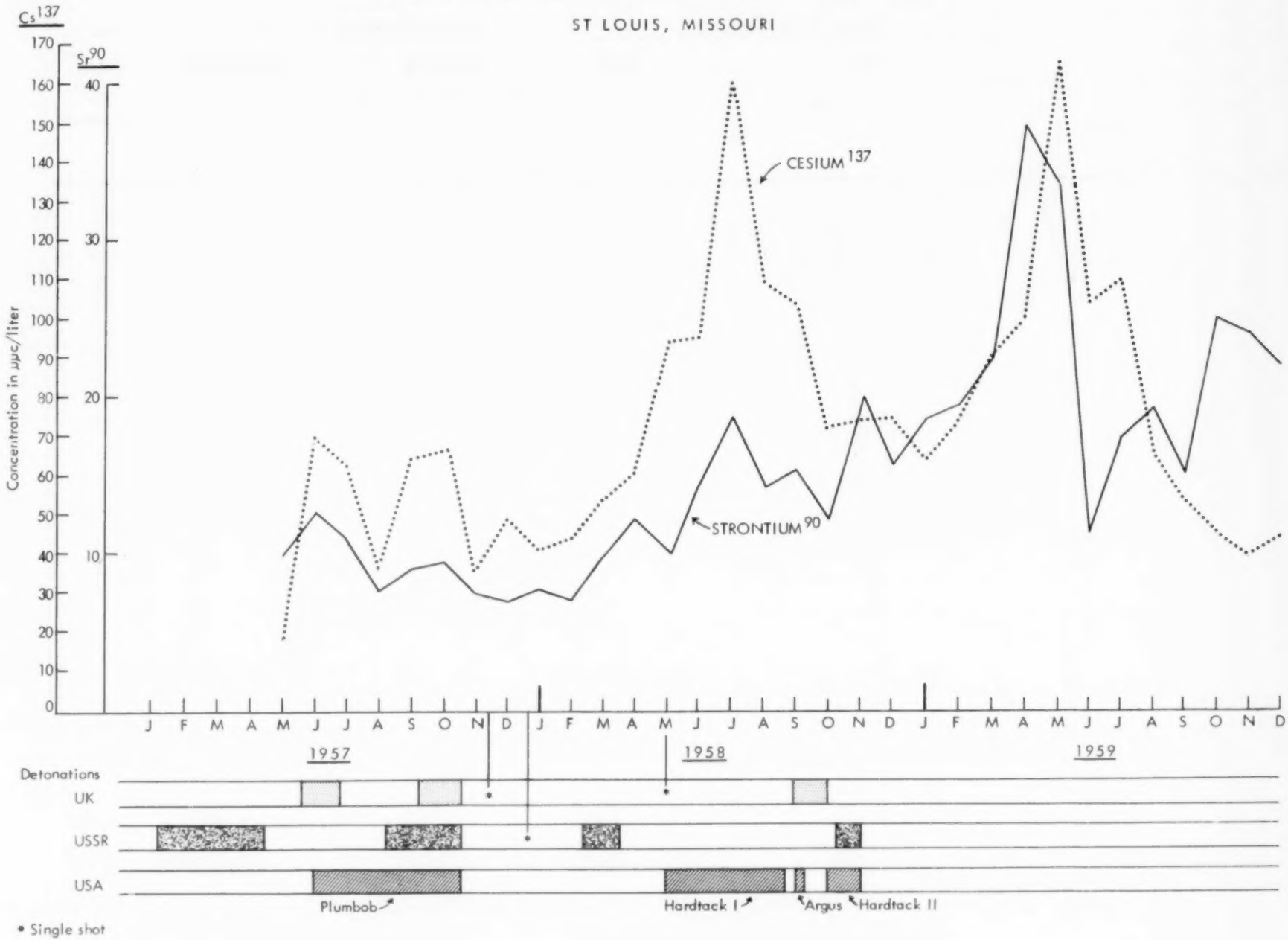
• Single shot

* Single shot

FIGURE 20

LONG LIVED RADIONUCLIDE CONCENTRATION IN MILK

ST LOUIS, MISSOURI



* Single shot

FIGURE 21

SHORT LIVED RADIONUCLIDE CONCENTRATION IN MILK
SPOKANE, WASH.

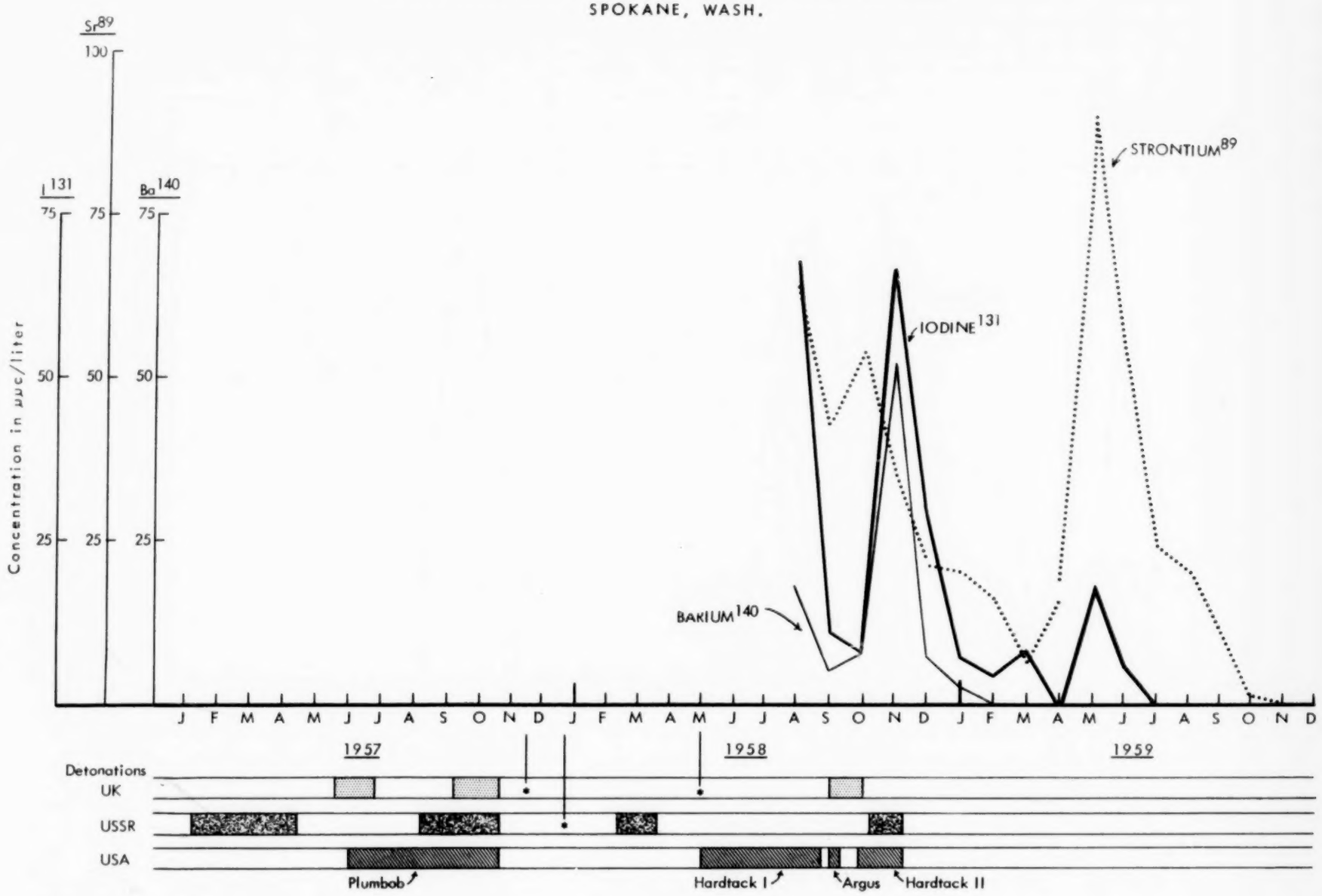
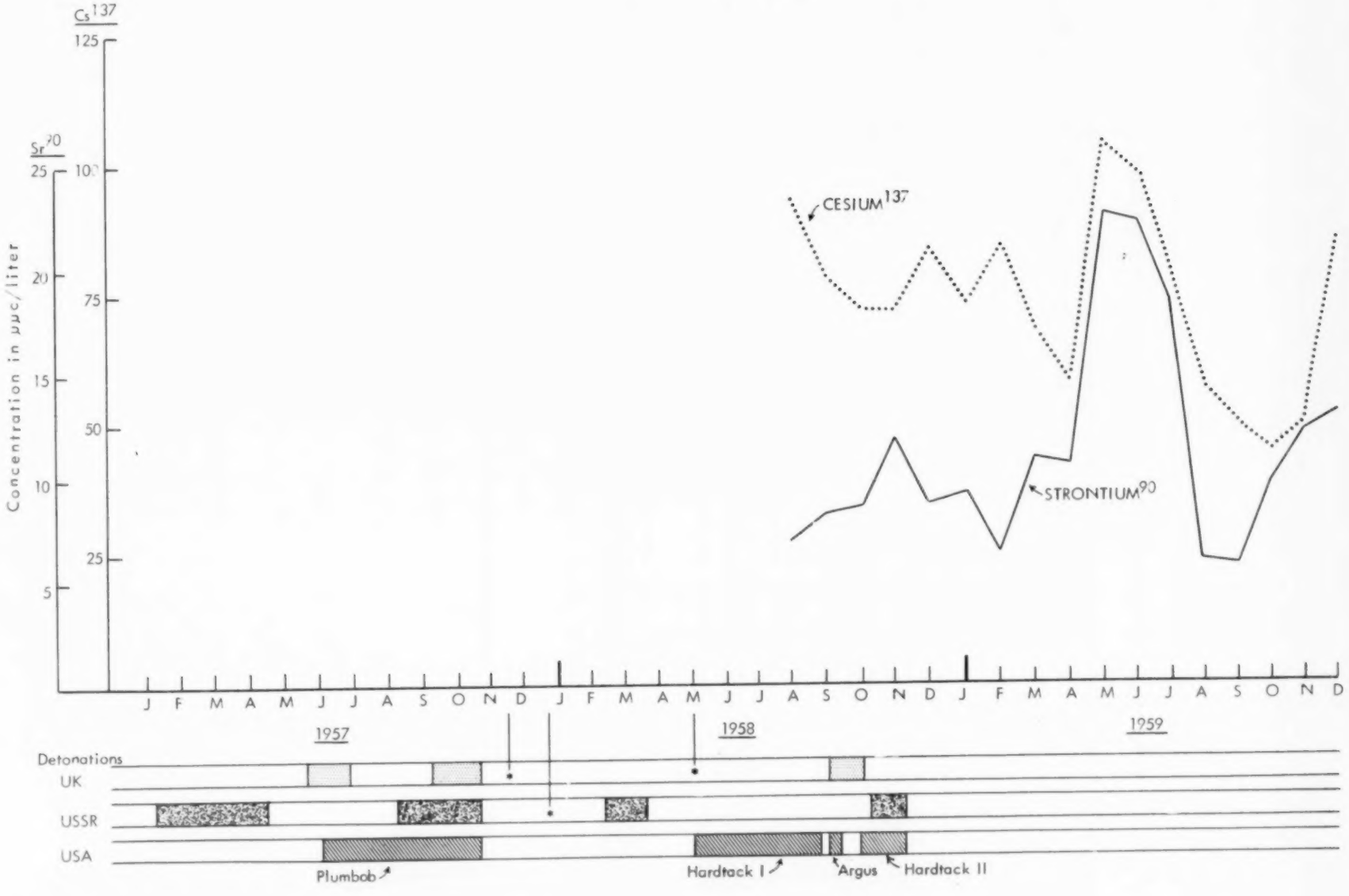


FIGURE 22

LONG LIVED RADIONUCLIDE CONCENTRATION IN MILK

SPOKANE, WASH.



• Single shot

STATE OF MINNESOTA MILK DATA

The Minnesota Department of Health, Division of Environmental Sanitation has reported the analyses of milk from September 1958 to December 1959. These results are contained in Table V.

TABLE V.--STRONTIUM-90 IN MILK COLLECTED AT SEVEN LOCATIONS IN MINNESOTA

(Micromicrocuries of Strontium-90 Per Liter of Milk)

Date collected	Location						
	Brainerd	Duluth	Fairbault	Minneapolis	Rochester	Thief River Falls	Worthington
5/58	23.0	24.0				9.7	
10/58		21.0	10.4	6.8			
11/58	19.5	21.0	10.7	12.5		14.0	
12/58	16.0	22.0	8.1	8.5		12.0	
1/59	19.6	16.4	13.6	14.0		15.9	
2/59	17.8	18.6	6.4	9.7		14.4	
3/59	16.4	21.6	12.6	9.9			7.0
4/59		20.3		10.4		12.6	7.2
5/59	17.8	30.7		16.9			12.8
6/59	32.4	25.9		16.8		16.3	12.1
7/59	23.3	16.0		10.4			9.9
8/59	18.1	15.8		7.7		9.7	6.2
9/59	16.4	15.3		8.2	8.7	9.3	5.4
10/59		17.0		10.0	10.7		5.6
11/59	27.5	15.2		10.2	6.3	12.1	
12/59	18.9	17.6			8.2		

*Samples are daily two ounce samples composited over a one month period.

SECTION III

AIR

PUBLIC HEALTH SERVICE RADIATION SURVEILLANCE NETWORK

The Public Health Service Radiation Surveillance Network was established in 1956 in cooperation with the Atomic Energy Commission to provide a means of promptly determining increases in environmental radiation due to radioactive fallout during nuclear weapons tests. The program has proven sufficiently valuable that it has been extended to a round-the-year basis and currently consists of 44 stations at urban locations (see figure 1) operated by State and local health department personnel with 3 operated by U. S. Public Health Service personnel.

Measurements of gross beta radioactivity in air have been taken since they provide one of the earliest and most sensitive indications of increases of activity in the environment, and thus act as an "alert" system. These data alone are not conducive to evaluation directly of biological hazards. However, field measurements do enable the operator to estimate the amount of beta activity of particulates in the air at the station five hours after collection, by comparison to a known source, using a portable survey meter. The filters are then forwarded to the laboratory in Washington for a more refined measurement using a thin window proportional counter.

Air samplers are in operation at the 44 stations on an average of 70% of the week. Air is drawn through a cellulose carbon loaded dust filter using a high volume air sampler. The radioactive material in fallout adhering to small dust-like particles is retained on the filter. Some gaseous fission products are adsorbed by the carbon. The contribution by gaseous fission products has represented only a small part of the total beta activity in these samples.

About 85% of the stations collect samples of precipitation which are sent to Washington for analysis. Values are now below limits of detection by present instrumentation. New equipment is being procured to measure lower values. Measurements have indicated that the bulk of deposited activity occurs through precipitation but concentrations in surface air are not directly relatable to the amount deposited through precipitation.

Table VI presents a summary of the latest monthly data.

Monthly averages of beta activity in air are shown for each station graphically in figures 24 through 67.

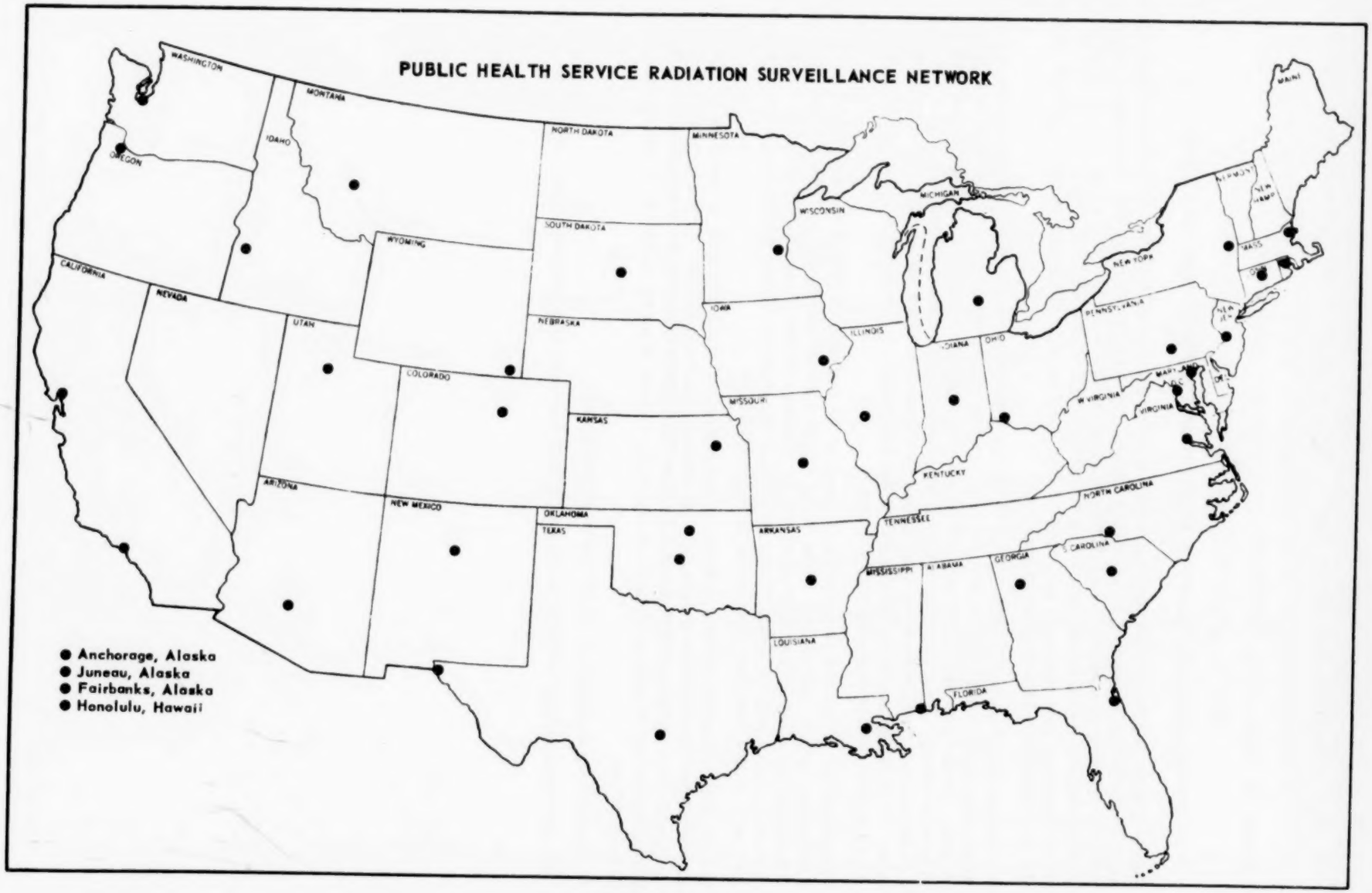

PUBLIC HEALTH SERVICE RADIATION SURVEILLANCE NETWORK
WASHINGTON
OREGON
CALIFORNIA
NEVADA
IDAHO
MONTANA
WYOMING
UTAH
ARIZONA
COLORADO
NEW MEXICO
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
TEXAS
MINNESOTA
IOWA
MISSOURI
ARKANSAS
LOUISIANA
WISCONSIN
ILLINOIS
MICHIGAN
INDIANA
OHIO
KENTUCKY
TENNESSEE
MISSISSIPPI
ALABAMA
GEORGIA
FLORIDA
S. CAROLINA
NORTH CAROLINA
VIRGINIA
W. VIRGINIA
PENNSYLVANIA
NEW YORK
MAINE
● Anchorage, Alaska
● Juneau, Alaska
● Fairbanks, Alaska
● Honolulu, Hawaii

FIGURE 23

TABLE VI.—PUBLIC HEALTH SERVICE RADIATION SURVEILLANCE NETWORK

Radioactivity of Particulates in Air
Micromicrocuries Per Cubic Meter—Gross Beta Counts
For month of February 1960

Station location	Weighted averages	Maximum	Minimum
Alaska, Anchorage	< 0.11	0.27	< 0.10
Alaska, Fairbanks	< 0.12	0.21	< 0.10
Alaska, Juneau	< 0.12	0.27	< 0.10
Arizona, Phoenix	0.29	0.66	0.20
Arkansas, Little Rock	< 0.12	0.17	< 0.10
California, Berkeley	< 0.17	0.38	< 0.10
California, Los Angeles	< 0.21	0.35	< 0.10
Colorado, Denver	< 0.29	1.38	< 0.10
Connecticut, Hartford	< 0.13	0.51	< 0.10
District of Columbia	< 0.16	0.44	< 0.10
Florida, Jacksonville	< 0.17	0.53	< 0.10
Georgia, Atlanta	< 0.20	0.51	< 0.10
Hawaii, Honolulu	< 0.16	0.33	< 0.10
Idaho, Boise	-	-	-
Illinois, Springfield	< 0.17	0.75	< 0.10
Indiana, Indianapolis	< 0.13	0.23	< 0.10
Iowa, Iowa City	< 0.14	0.23	< 0.10
Kansas, Topeka	< 0.12	0.18	< 0.10
Louisiana, New Orleans	< 0.19	0.31	< 0.10
Maryland, Baltimore	< 0.15	0.31	< 0.10
Massachusetts, Lawrence	< 0.10	0.13	< 0.10
Michigan, Lansing	< 0.12	0.17	< 0.10
Minnesota, Minneapolis	< 0.12	0.18	< 0.10
Mississippi, Pascagoula	< 0.23	0.64	< 0.10
Missouri, Jefferson City	< 0.13	0.17	< 0.10
Montana, Helena	< 0.16	0.28	< 0.10
New Jersey, Trenton	< 0.12	0.18	< 0.10
New Mexico, Santa Fe	< 0.27	0.79	< 0.10
New York, Albany	< 0.11	0.17	< 0.10
North Carolina, Gastonia	< 0.20	0.47	< 0.10
Ohio, Cincinnati	0.30	0.70	0.09
Oklahoma, Oklahoma City	< 0.15	0.28	< 0.10
Oklahoma, Ponca City	< 0.10	0.19	< 0.10
Oregon, Portland	< 0.17	0.35	< 0.10
Pennsylvania, Harrisburg	< 0.16	0.30	< 0.10
Rhode Island, Providence	< 0.14	0.31	< 0.10
South Carolina, Columbia	< 0.16	0.36	< 0.10
South Dakota, Pierre	< 0.15	0.23	< 0.10
Texas, Austin	< 0.16	1.08	< 0.10
Texas, El Paso	0.38	1.45	0.11
Utah, Salt Lake City	< 0.23	1.70	< 0.10
Virginia, Richmond	< 0.13	0.26	< 0.10
Washington, Seattle	< 0.14	0.36	< 0.10
Wyoming, Cheyenne	< 0.15	0.25	< 0.10

BETA ACTIVITY OF AIR-BORNE PARTICULATES
Anchorage, Alaska
Radiation Surveillance Network

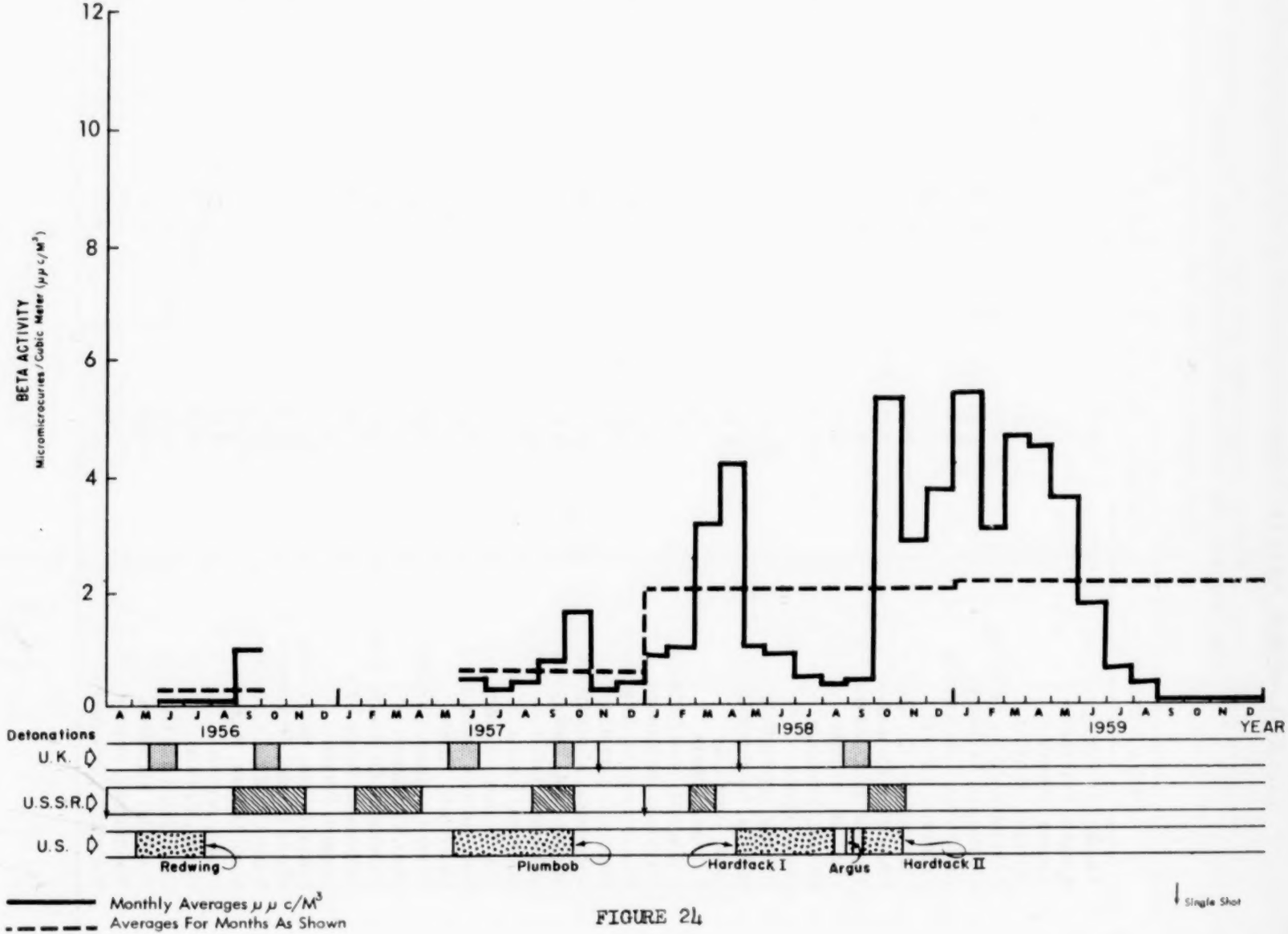


FIGURE 24

BETA ACTIVITY OF AIR-BORNE PARTICULATES
Fairbanks, Alaska
Radiation Surveillance Network

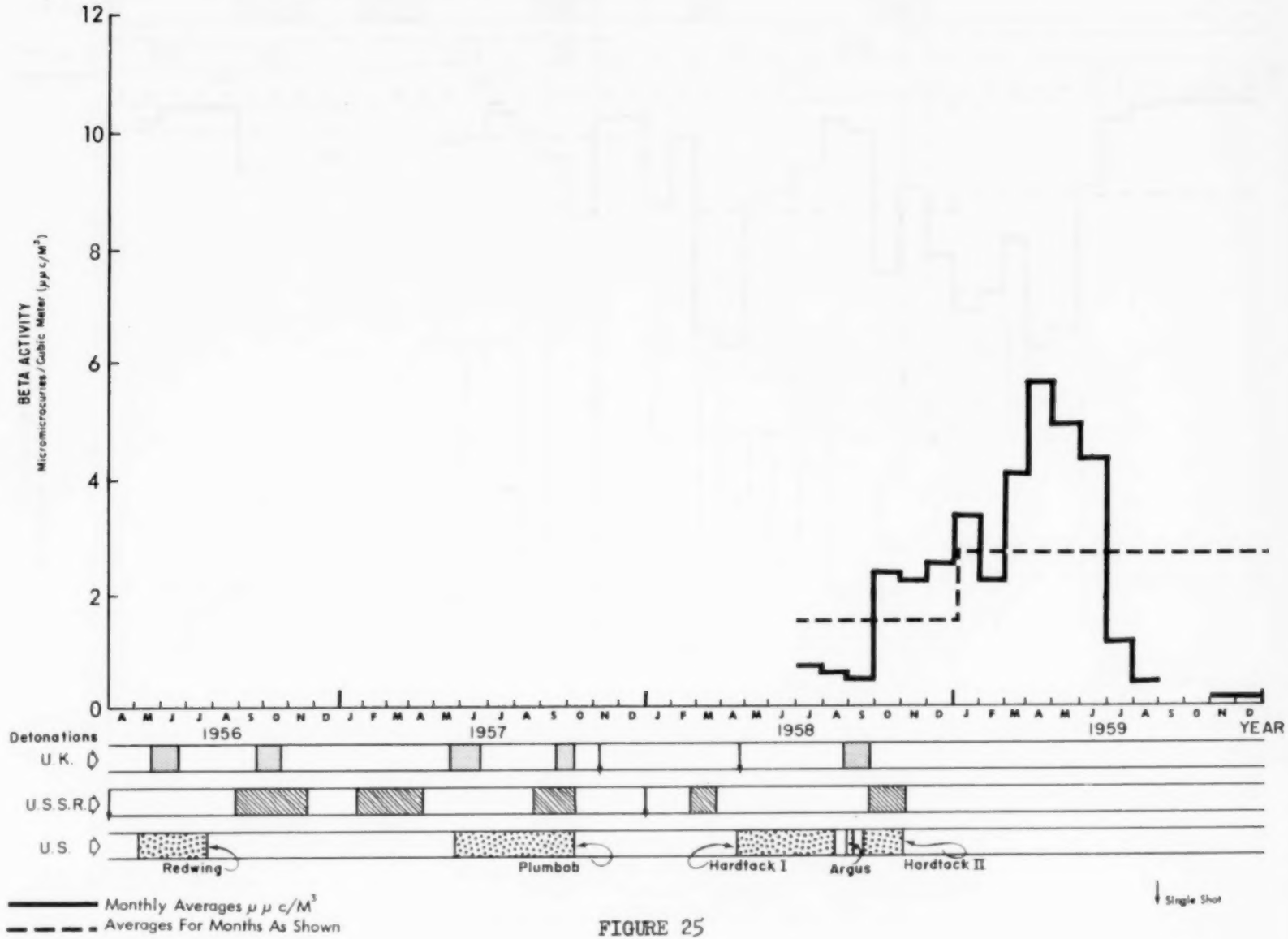


FIGURE 25

BETA ACTIVITY OF AIR-BORNE PARTICULATES
Juneau, Alaska
Radiation Surveillance Network

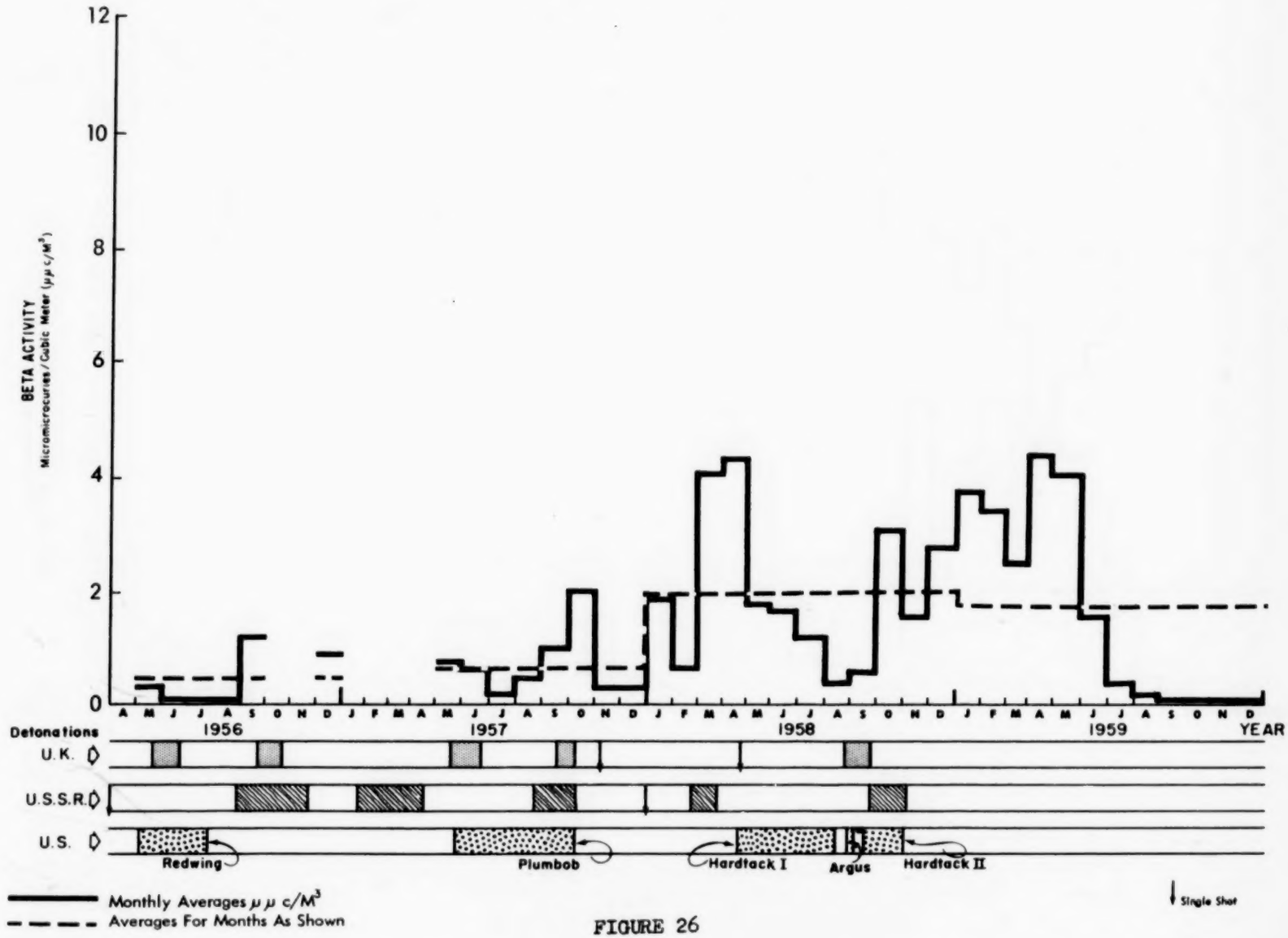


FIGURE 26

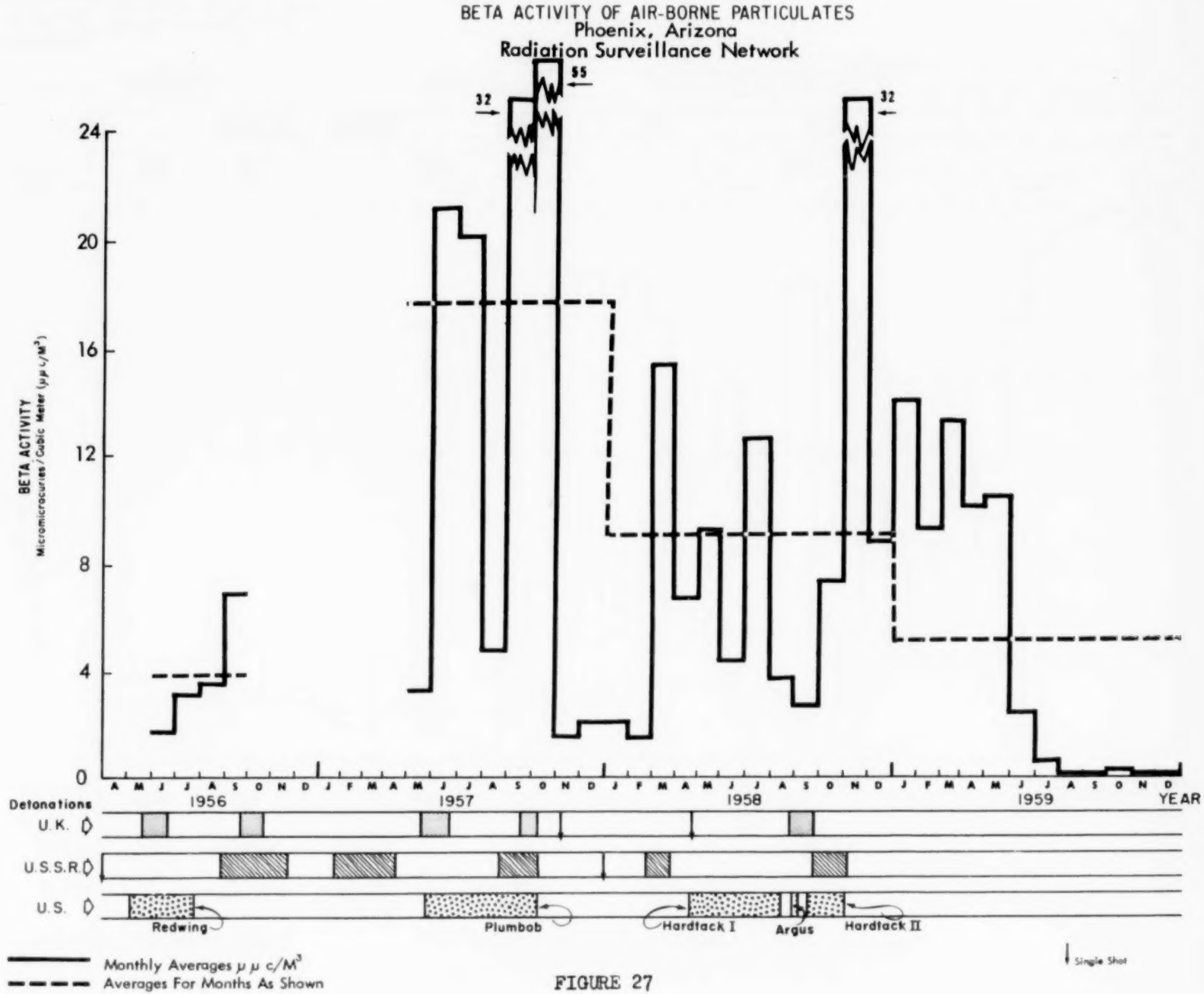

BETA ACTIVITY OF AIR-BORNE PARTICULATES
Phoenix, Arizona
Radiation Surveillance Network
BETA ACTIVITY
Micromicrocuries/Cubic Meter (μμc/M³)
24
20
16
12
8
4
0
32
55
32
A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1956
1957
1958
1959
YEAR
Detonations
U.K.
U.S.S.R.
U.S.
Redwing
Plumbob
Hardtack I
Argus
Hardtack II
Single Shot
Monthly Averages μ μ c/M³
Averages For Months As Shown

FIGURE 27

BETA ACTIVITY OF AIR-BORNE PARTICULATES
Little Rock, Arkansas
Radiation Surveillance Network

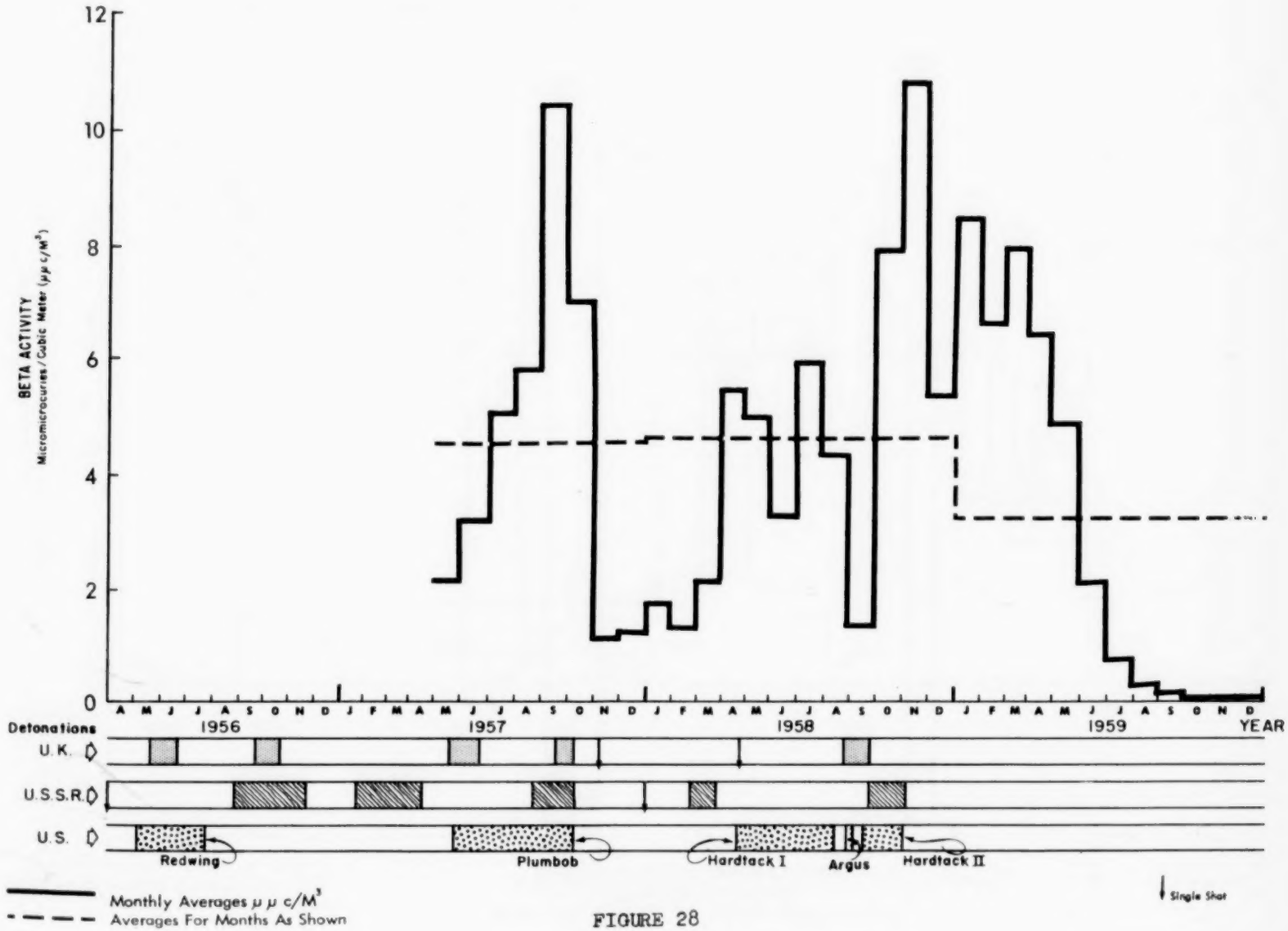


FIGURE 28

BETA ACTIVITY OF AIR-BORNE PARTICULATES

Averages For Months As Shown

FIGURE 28

BETA ACTIVITY OF AIR-BORNE PARTICULATES
Berkeley, California
Radiation Surveillance Network

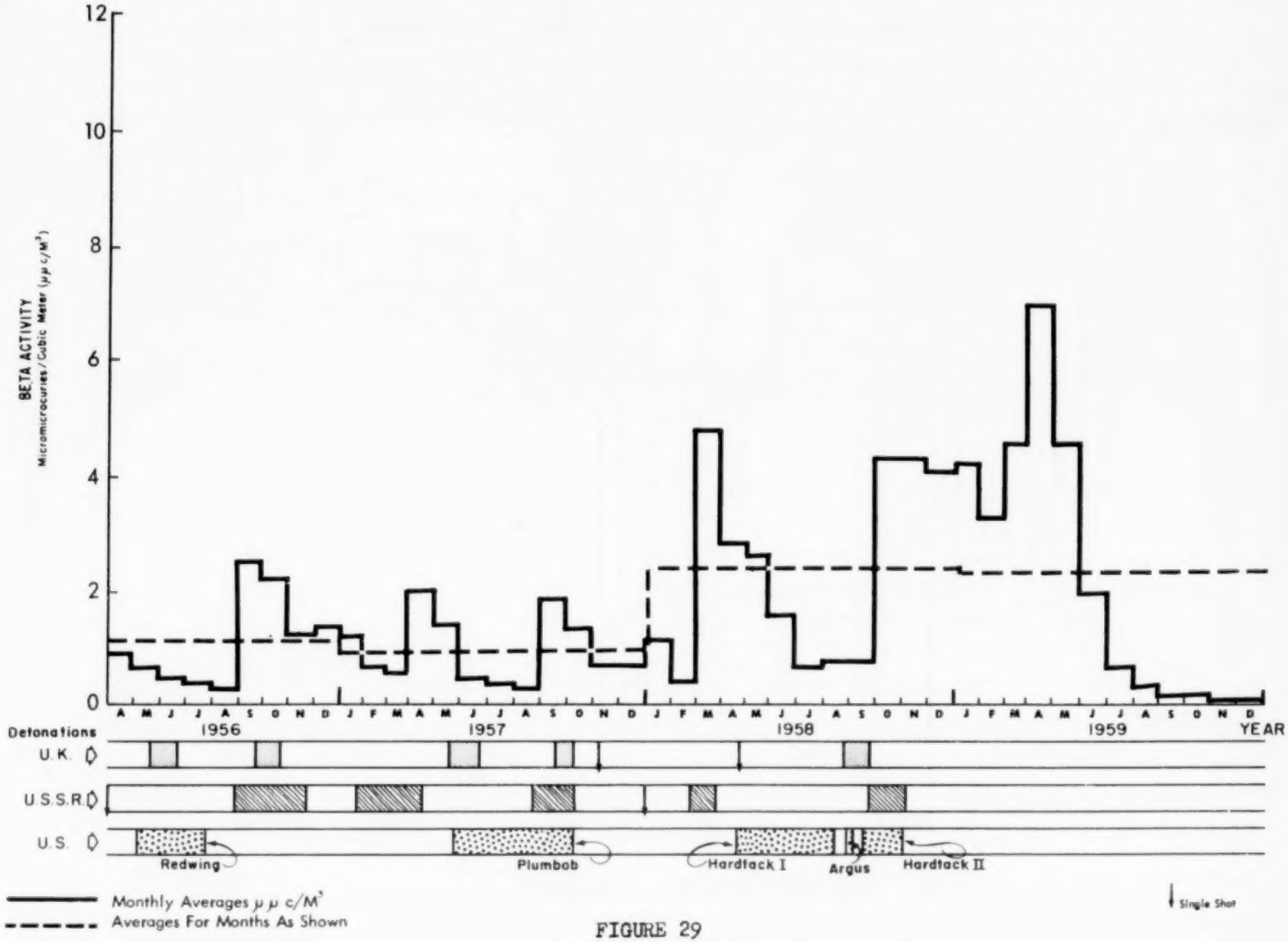


FIGURE 29

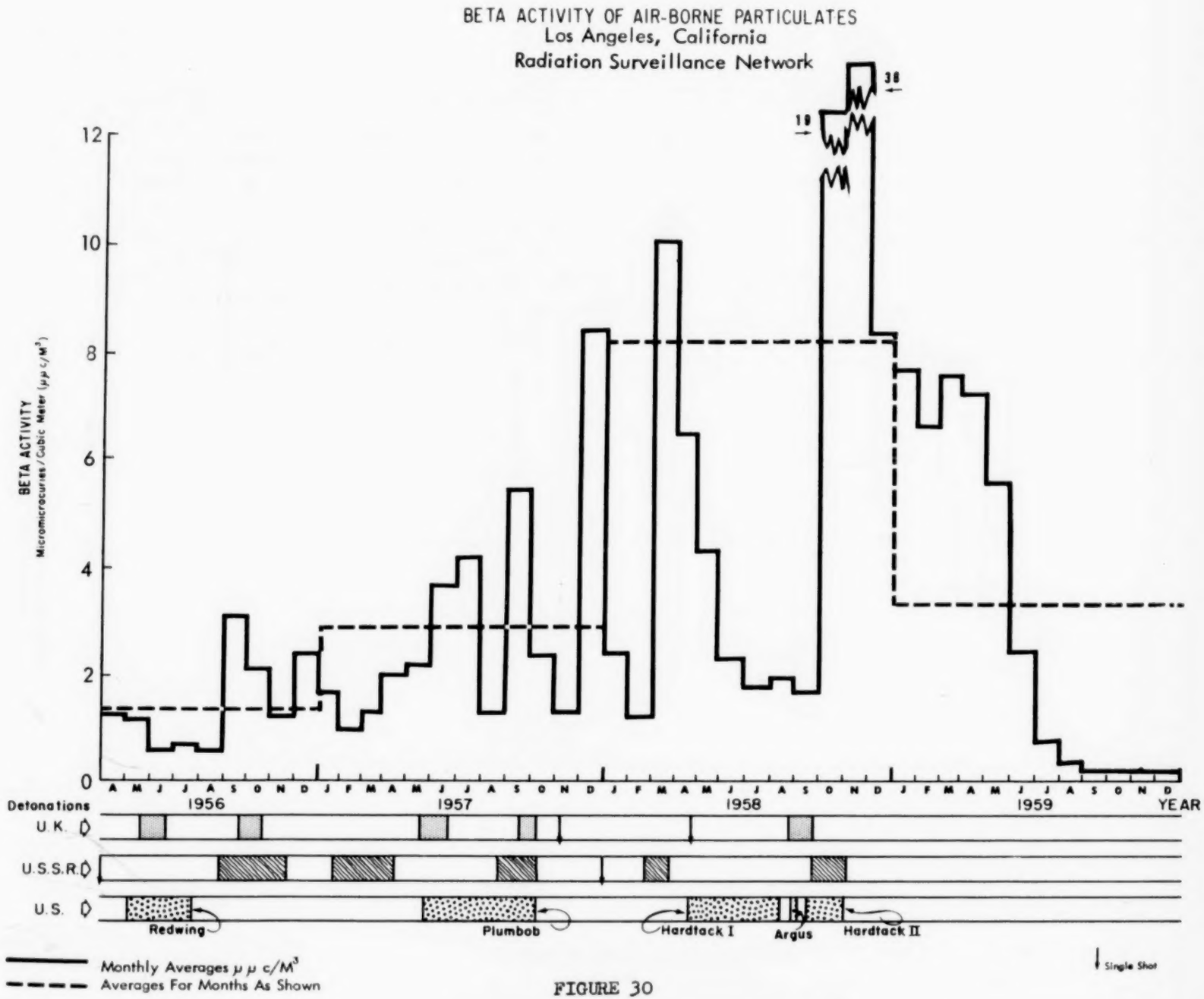

BETA ACTIVITY OF AIR-BORNE PARTICULATES
Los Angeles, California
Radiation Surveillance Network
38
19
12
10
8
6
4
2
0
BETA ACTIVITY
Micromicrocuries / Cubic Meter (μμ c/M³)
A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1956
1957
1958
1959
YEAR
Detonations
U.K.
U.S.S.R.
U.S.
Redwing
Plumbob
Hardtack I
Argus
Hardtack II
Single Shot
Monthly Averages μ μ c/M³
Averages For Months As Shown

FIGURE 30

Averages For Months As Shown

FIGURE 30

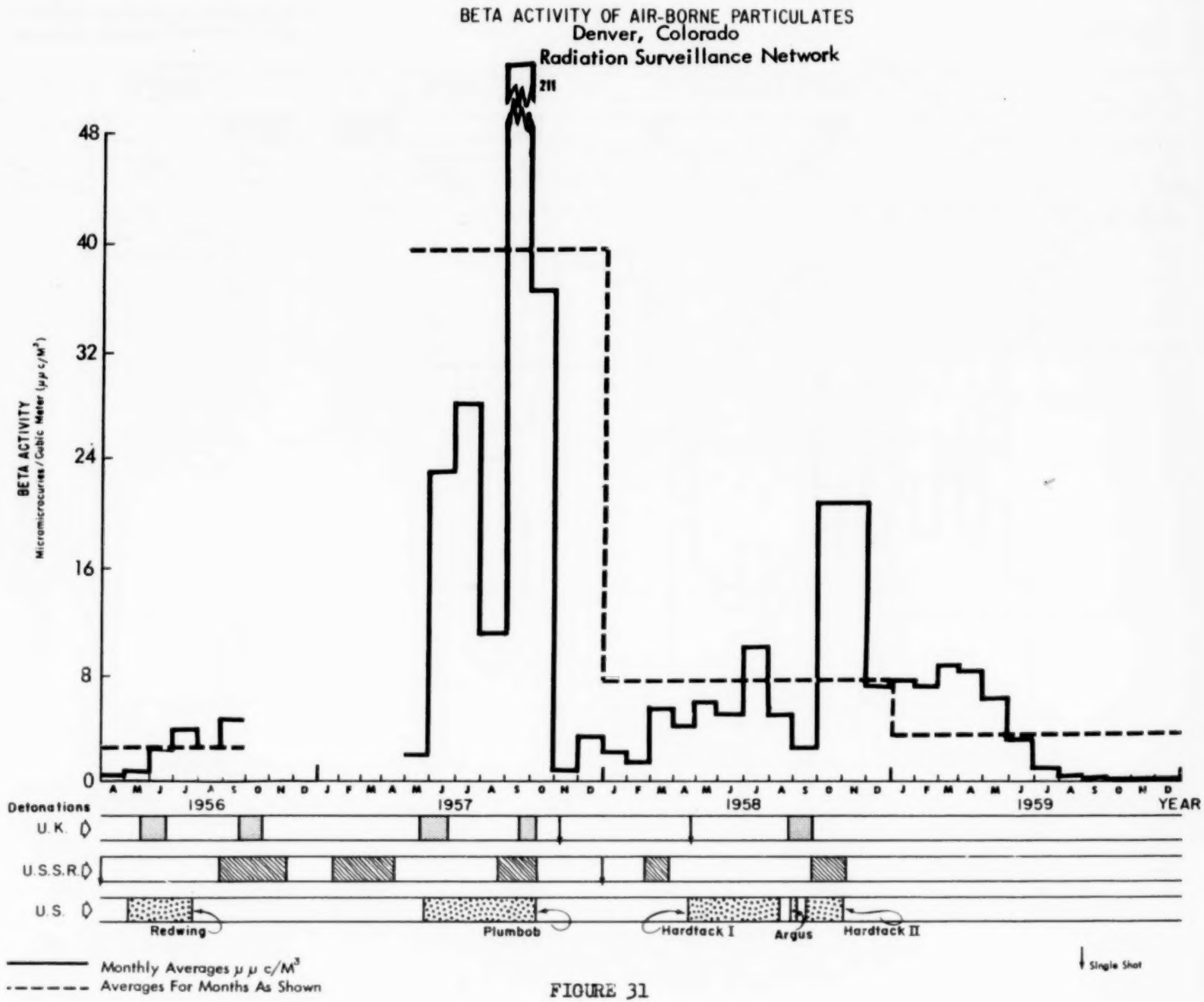


FIGURE 31

BETA ACTIVITY OF AIR-BORNE PARTICULATES
Hartford, Connecticut
Radiation Surveillance Network

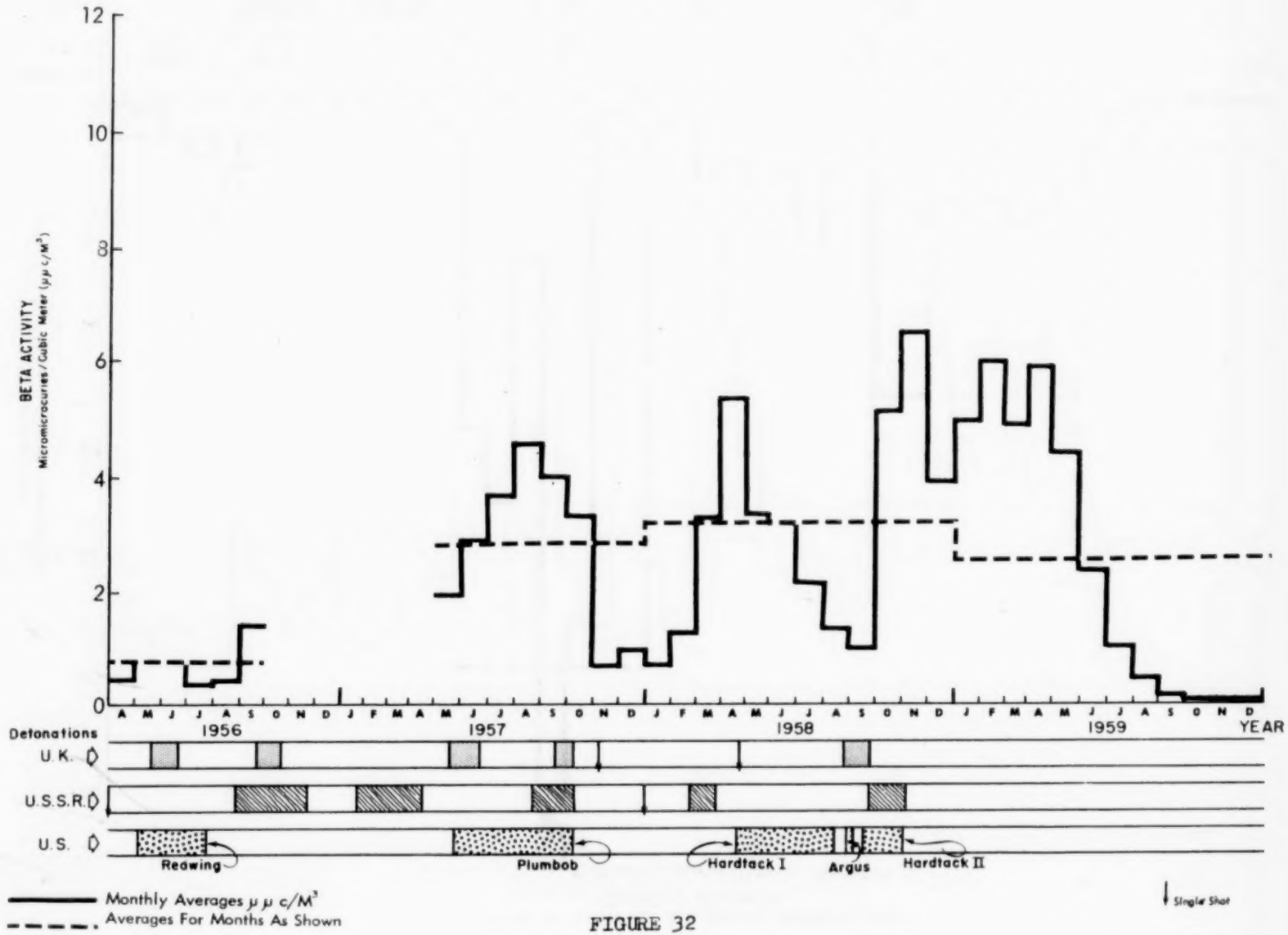


FIGURE 32

Averages For Months As Shown

FIGURE 32

BETA ACTIVITY OF AIR-BORNE PARTICULATES
Washington, D. C.
Radiation Surveillance Network

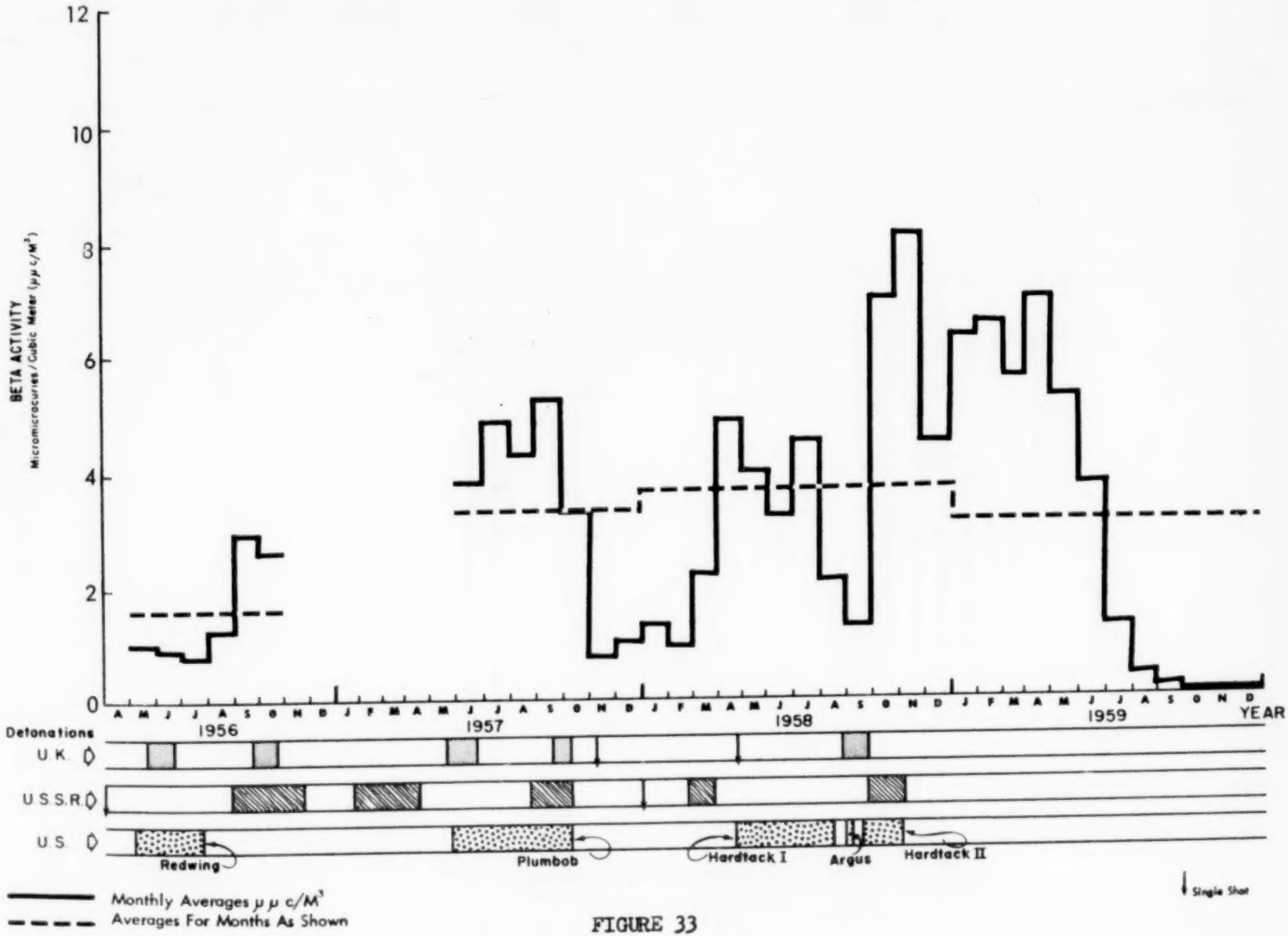


FIGURE 33

BETA ACTIVITY OF AIR-BORNE PARTICULATES
Jacksonville, Florida
Radiation Surveillance Network

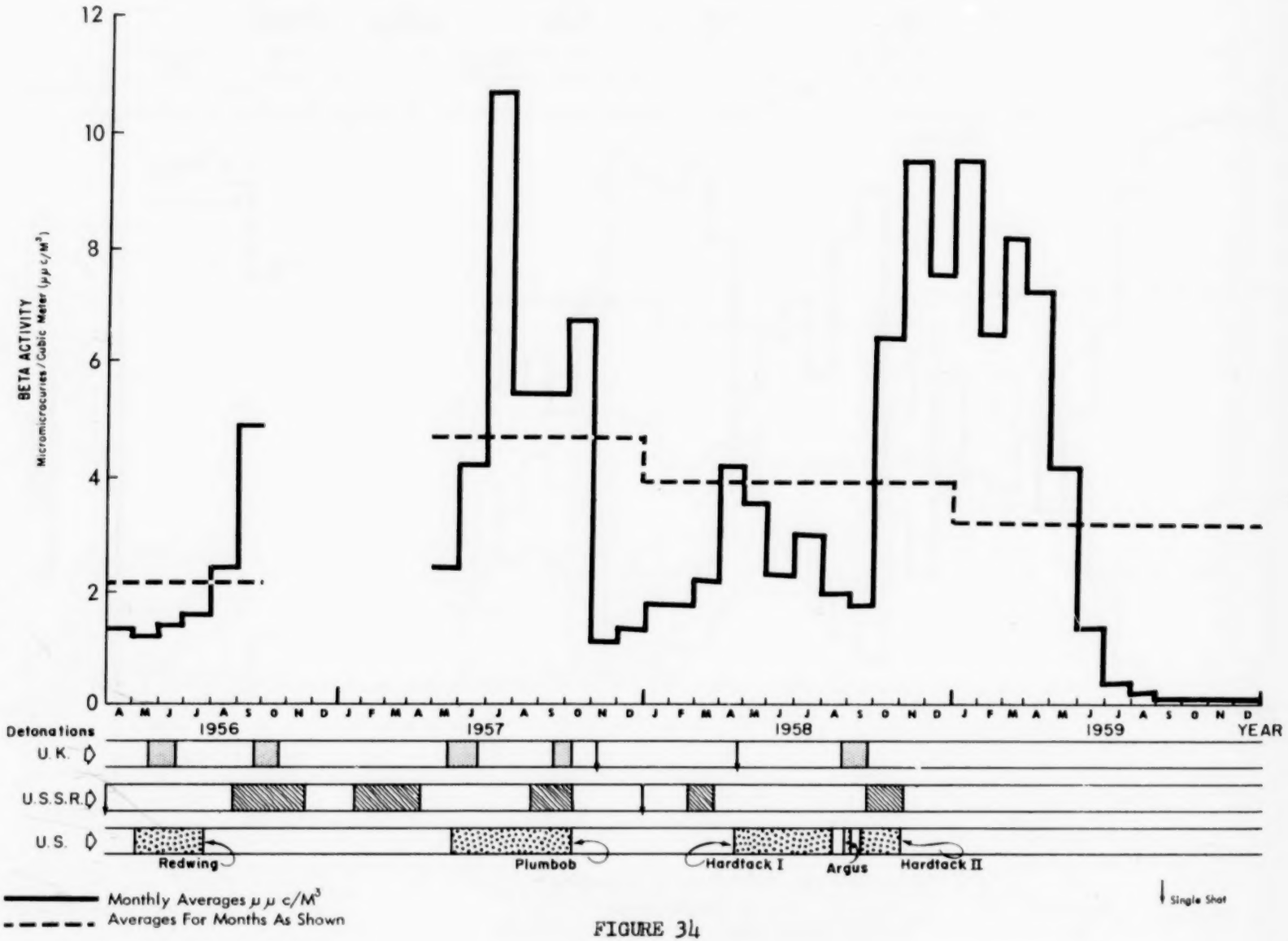


FIGURE 34

BETA ACTIVITY OF AIR-BORNE PARTICULATES
Atlanta, Georgia
Radiation Surveillance Network

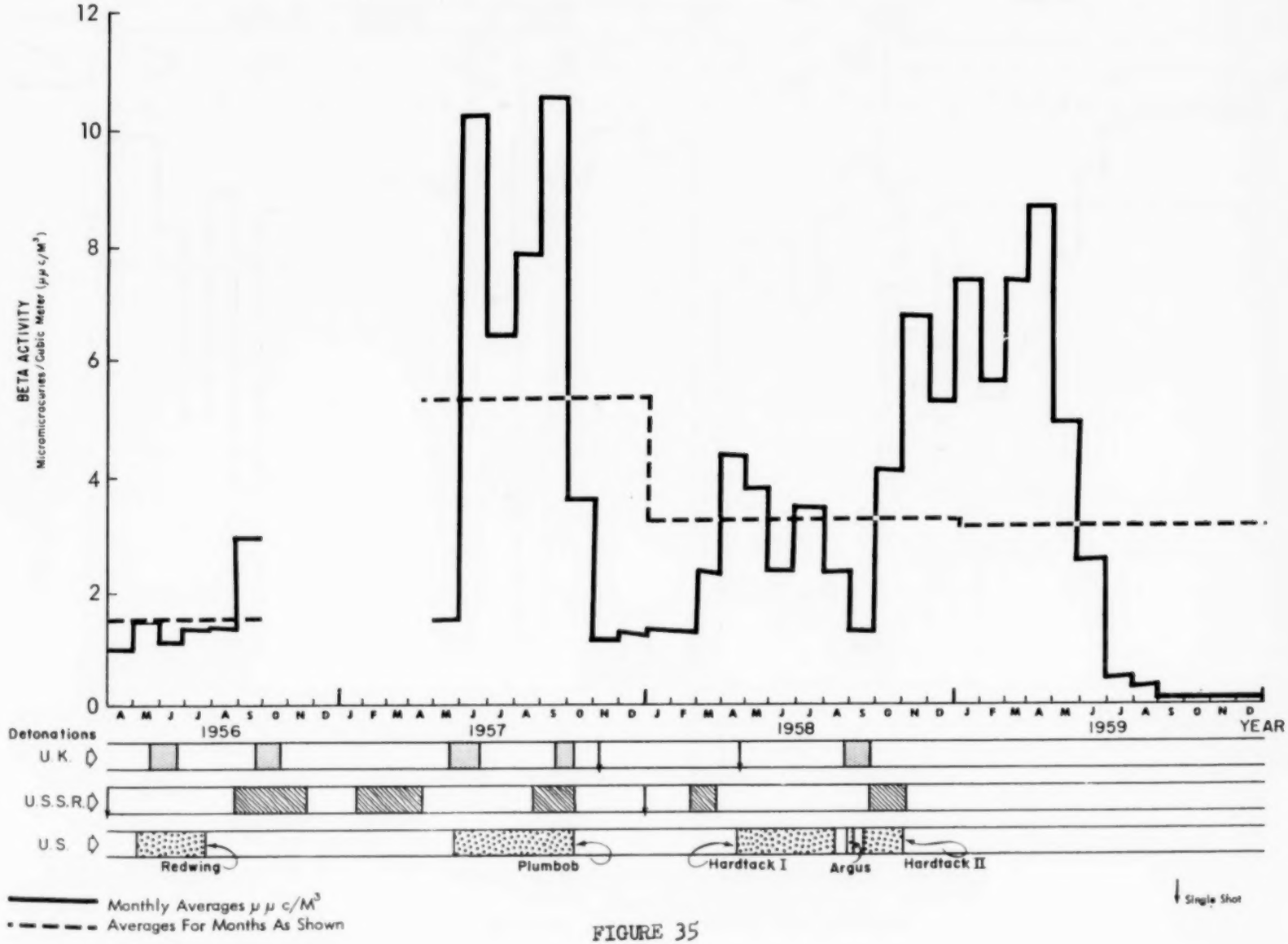


FIGURE 35

BETA ACTIVITY OF AIR-BORNE PARTICULATES
Honolulu, Hawaii
Radiation Surveillance Network

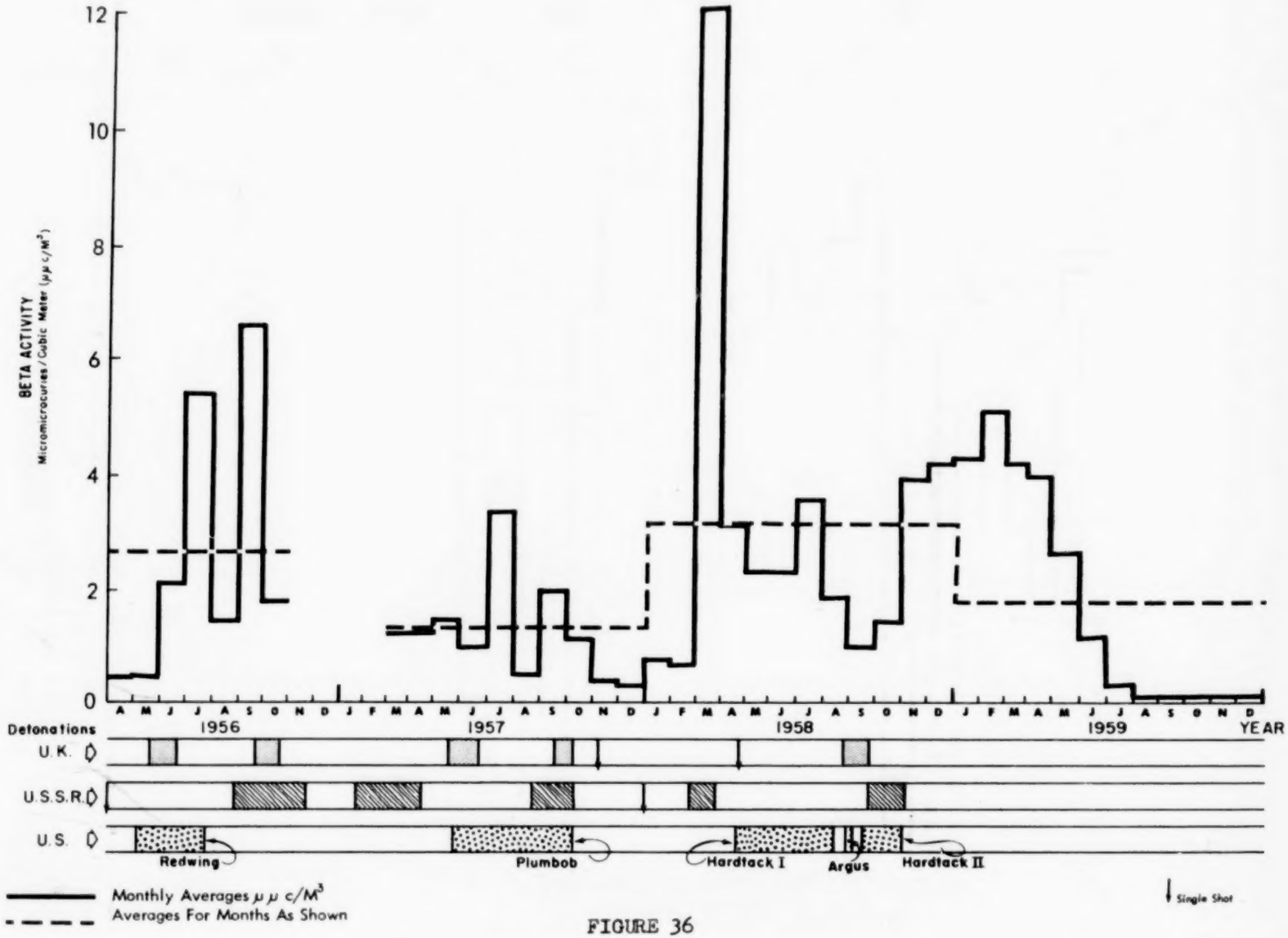


FIGURE 36

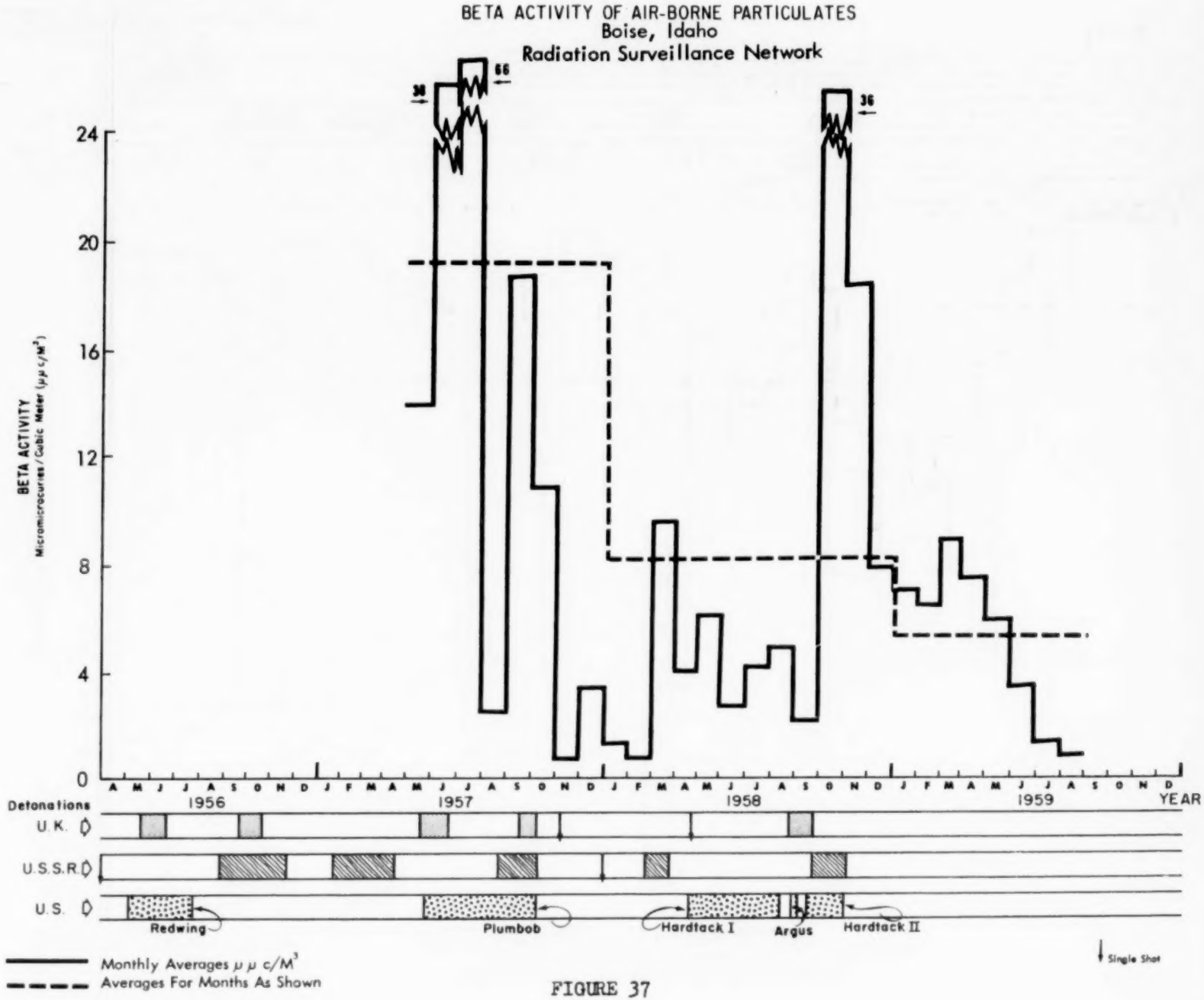

BETA ACTIVITY OF AIR-BORNE PARTICULATES
Boise, Idaho
Radiation Surveillance Network
BETA ACTIVITY
Micromicrocuries / Cubic Meter (μμ c/M³)
24
20
16
12
8
4
0
38
66
36
A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1956
1957
1958
1959
YEAR
Detonations
U.K.
U.S.S.R.
U.S.
Redwing
Plumbob
Hardtack I
Argus
Hardtack II
Single Shot
Monthly Averages μ μ c/M³
Averages For Months As Shown

FIGURE 37

BETA ACTIVITY OF AIR-BORNE PARTICULATES
Springfield, Illinois
Radiation Surveillance Network

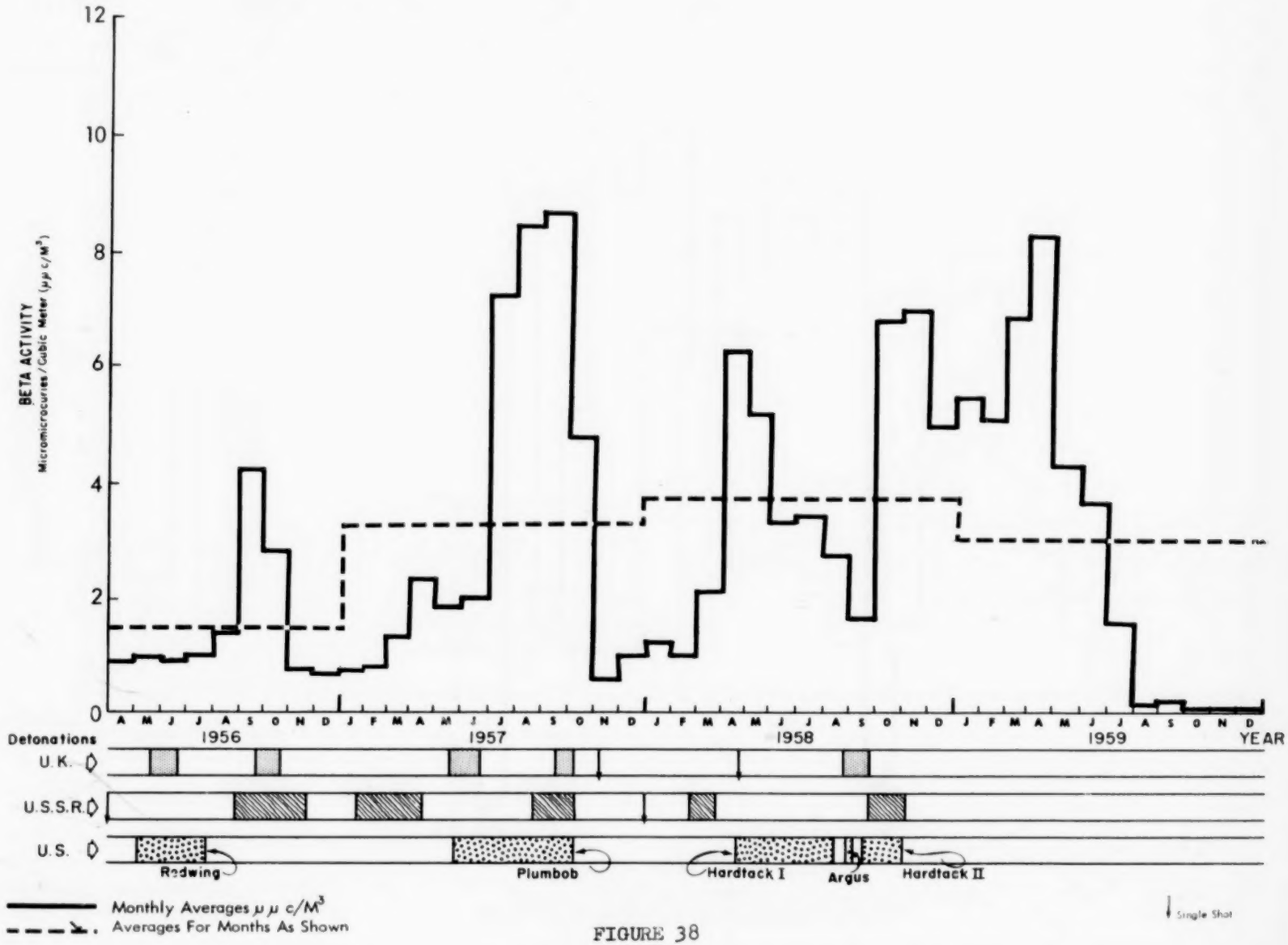


FIGURE 38

Averages For Months As Shown

FIGURE 38

BETA ACTIVITY OF AIR-BORNE PARTICULATES
Indianapolis, Indiana
Radiation Surveillance Network

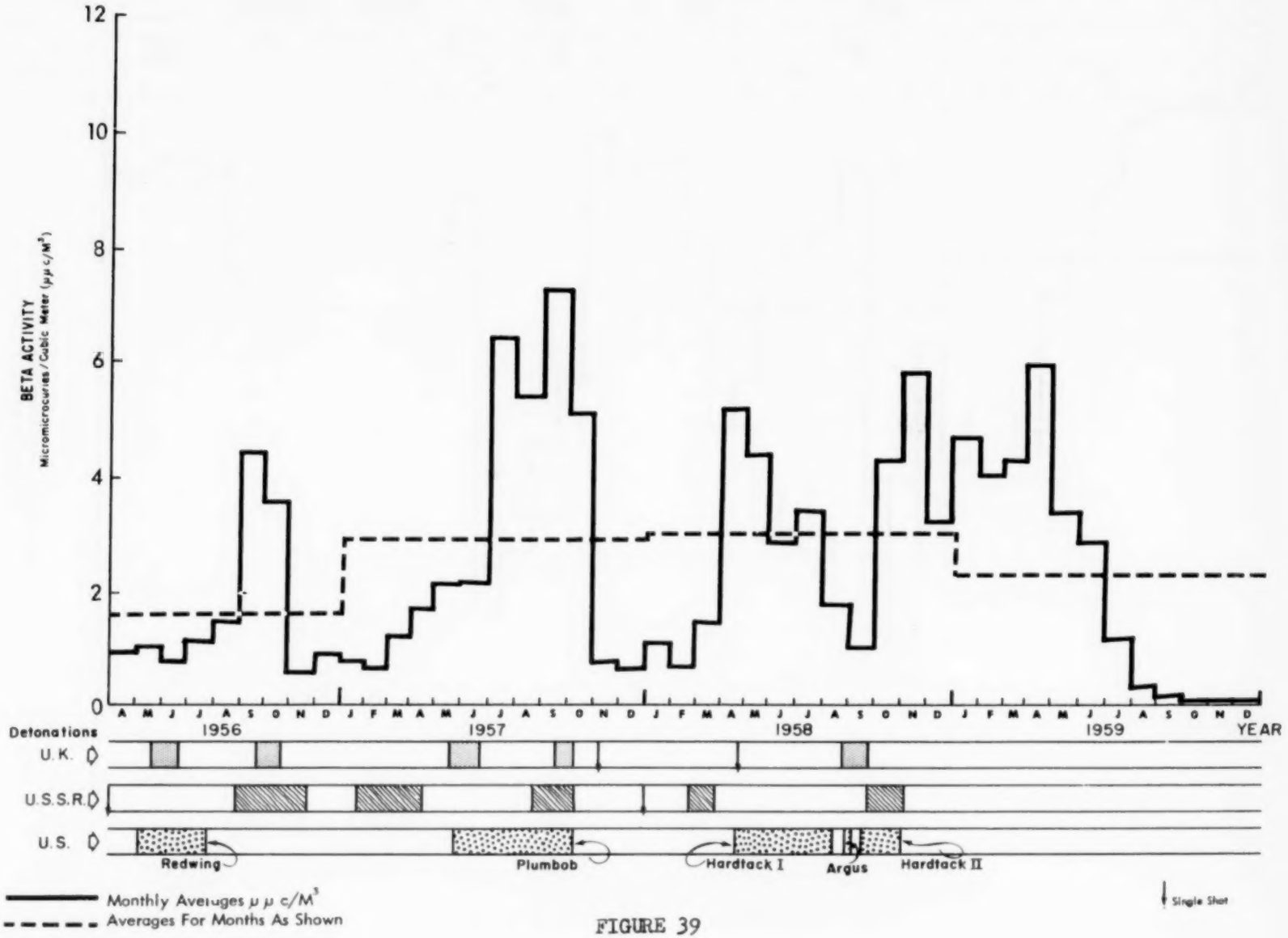


FIGURE 39

BETA ACTIVITY OF AIR-BORNE PARTICULATES
Iowa City, Iowa
Radiation Surveillance Network

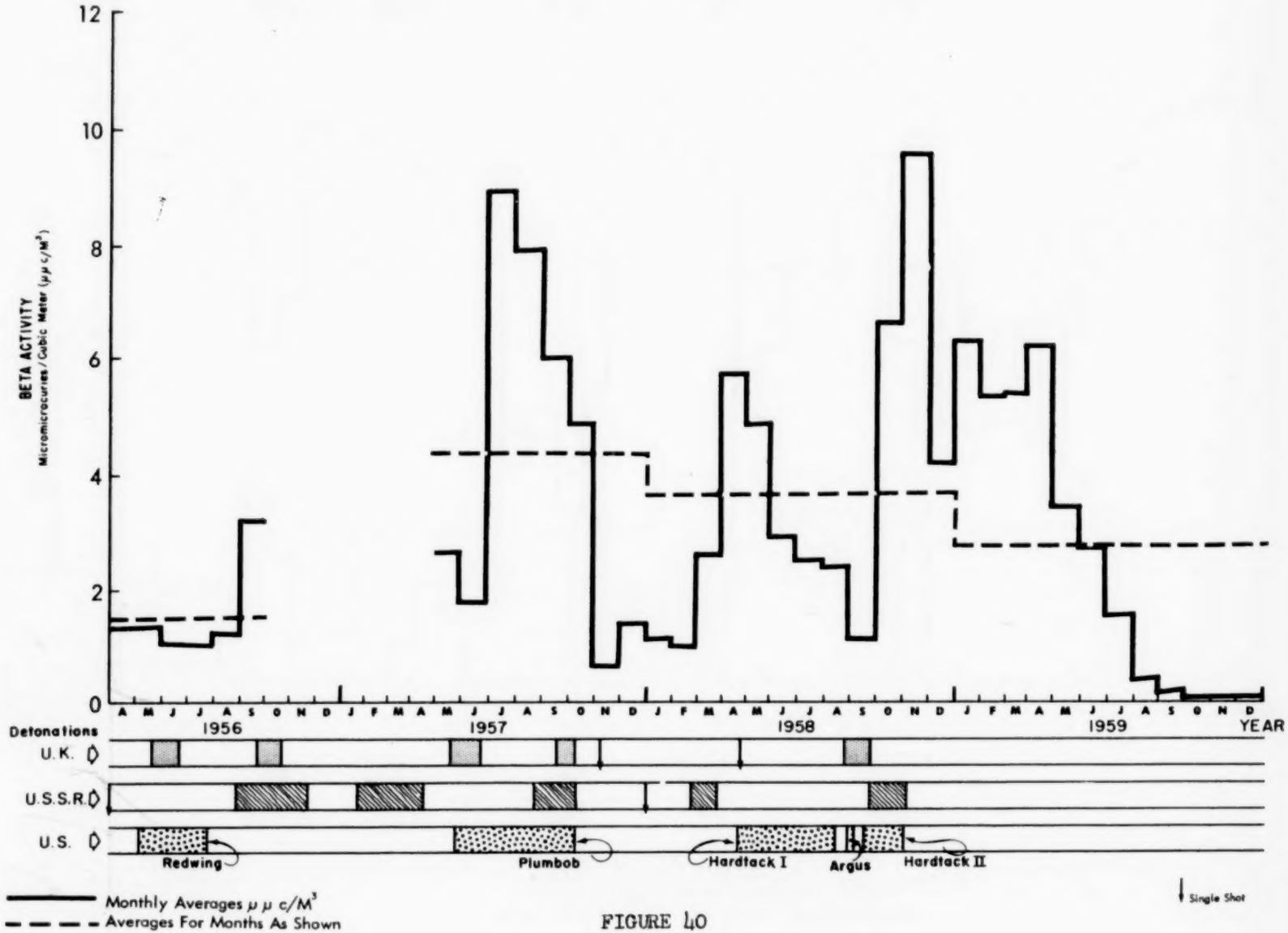


FIGURE 40

BETA ACTIVITY OF AIR-BORNE PARTICULATES
Topeka, Kansas
Radiation Surveillance Network

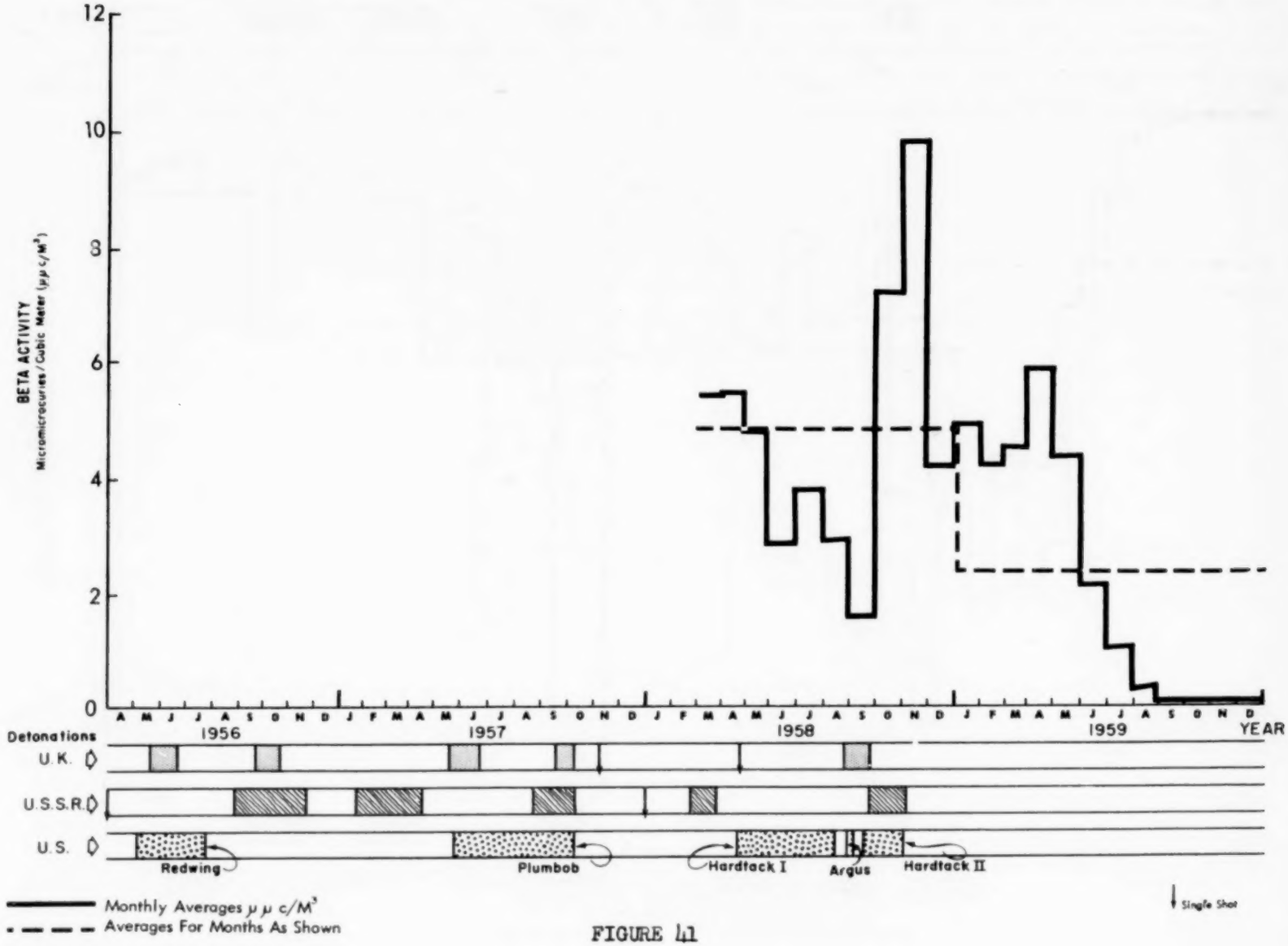


FIGURE 41

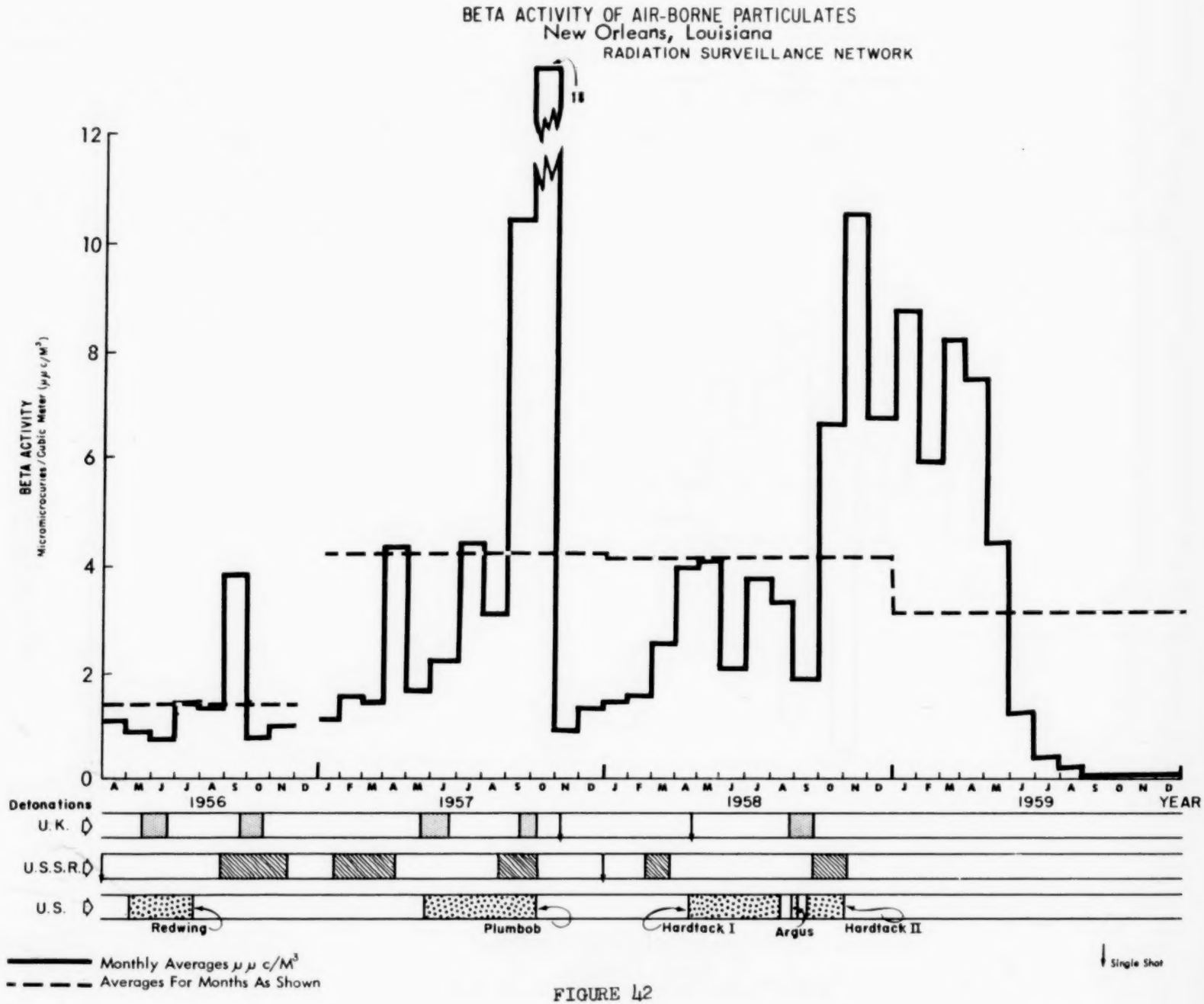

BETA ACTIVITY OF AIR-BORNE PARTICULATES
New Orleans, Louisiana
RADIATION SURVEILLANCE NETWORK
BETA ACTIVITY
Micromicrocuries/Cubic Meter (μμc/M³)
12
10
8
6
4
2
0
A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1956
1957
1958
1959
YEAR
Detonations
U.K.
U.S.S.R.
U.S.
Redwing
Plumbob
Hardtack I
Argus
Hardtack II
Monthly Averages μμ c/M³
Averages For Months As Shown
Single Shot

FIGURE 42

BETA ACTIVITY OF AIR-BORNE PARTICULATES
Baltimore, Maryland
Radiation Surveillance Network

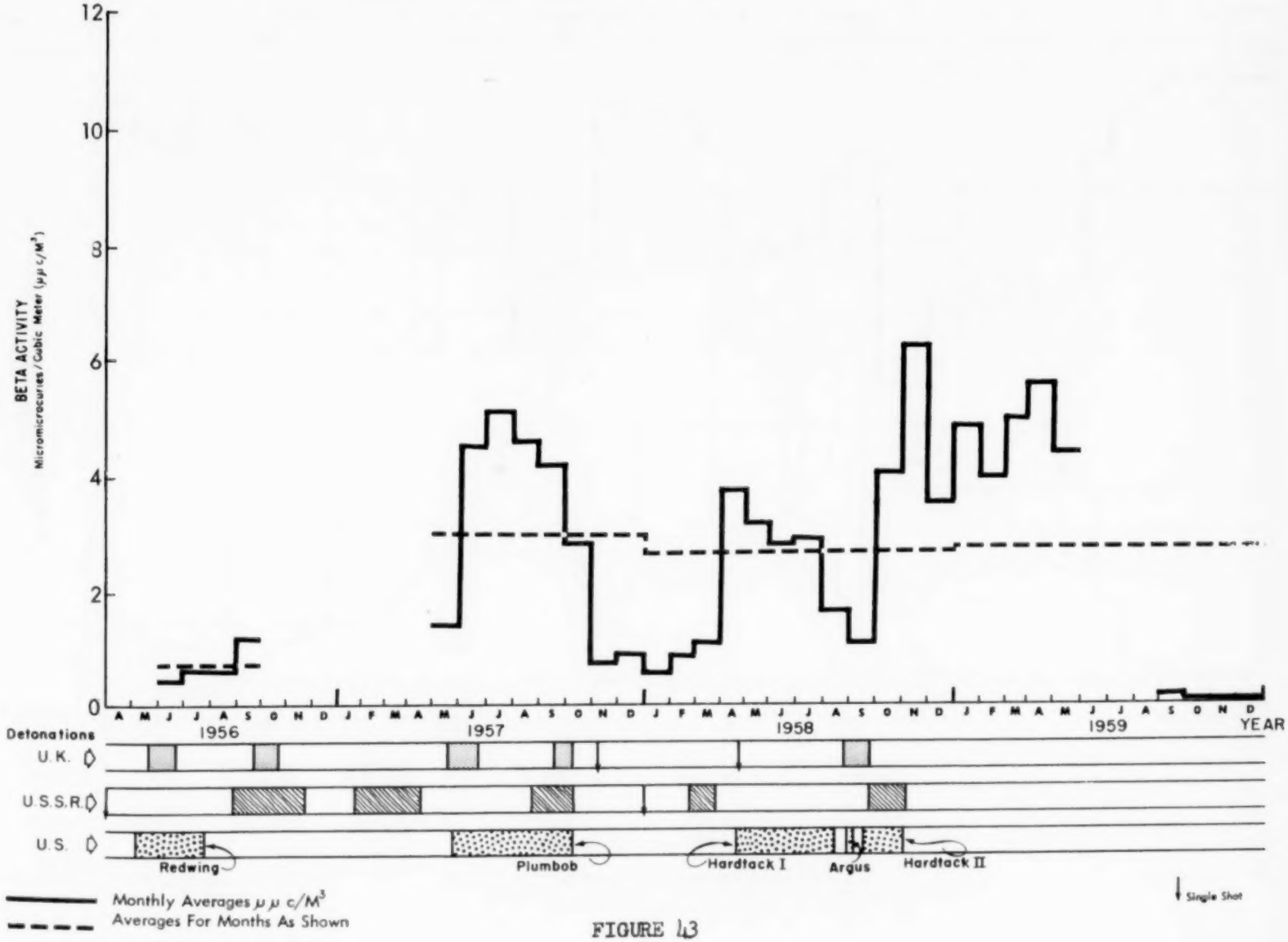


FIGURE 43

BETA ACTIVITY OF AIR-BORNE PARTICULATES
Lawrence, Massachusetts
Radiation Surveillance Network

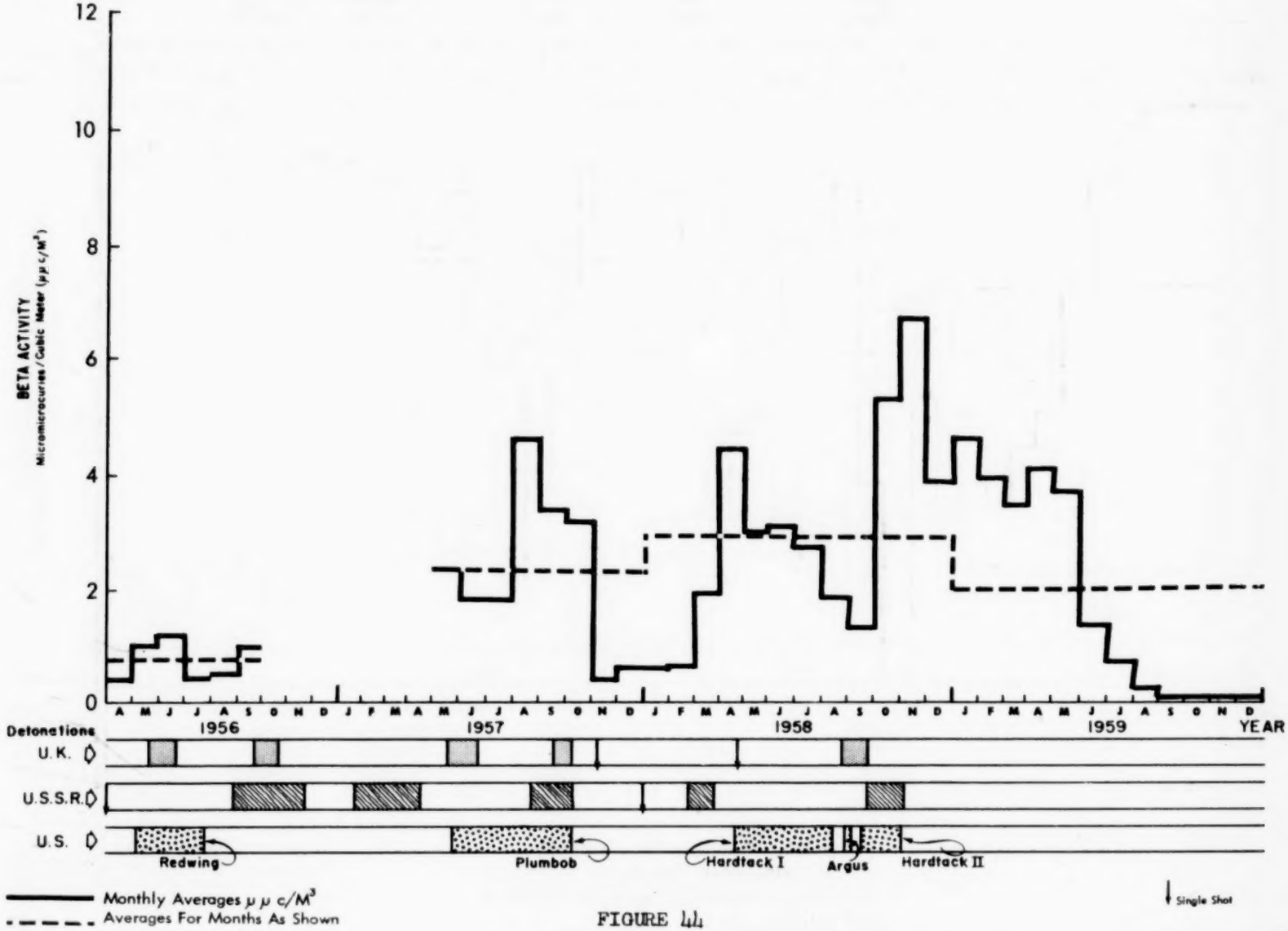


FIGURE 44

BETA ACTIVITY OF AIR-BORNE PARTICULATES

Averages For Months As Shown

FIGURE 44

BETA ACTIVITY OF AIR-BORNE PARTICULATES
Lansing, Michigan
Radiation Surveillance Network

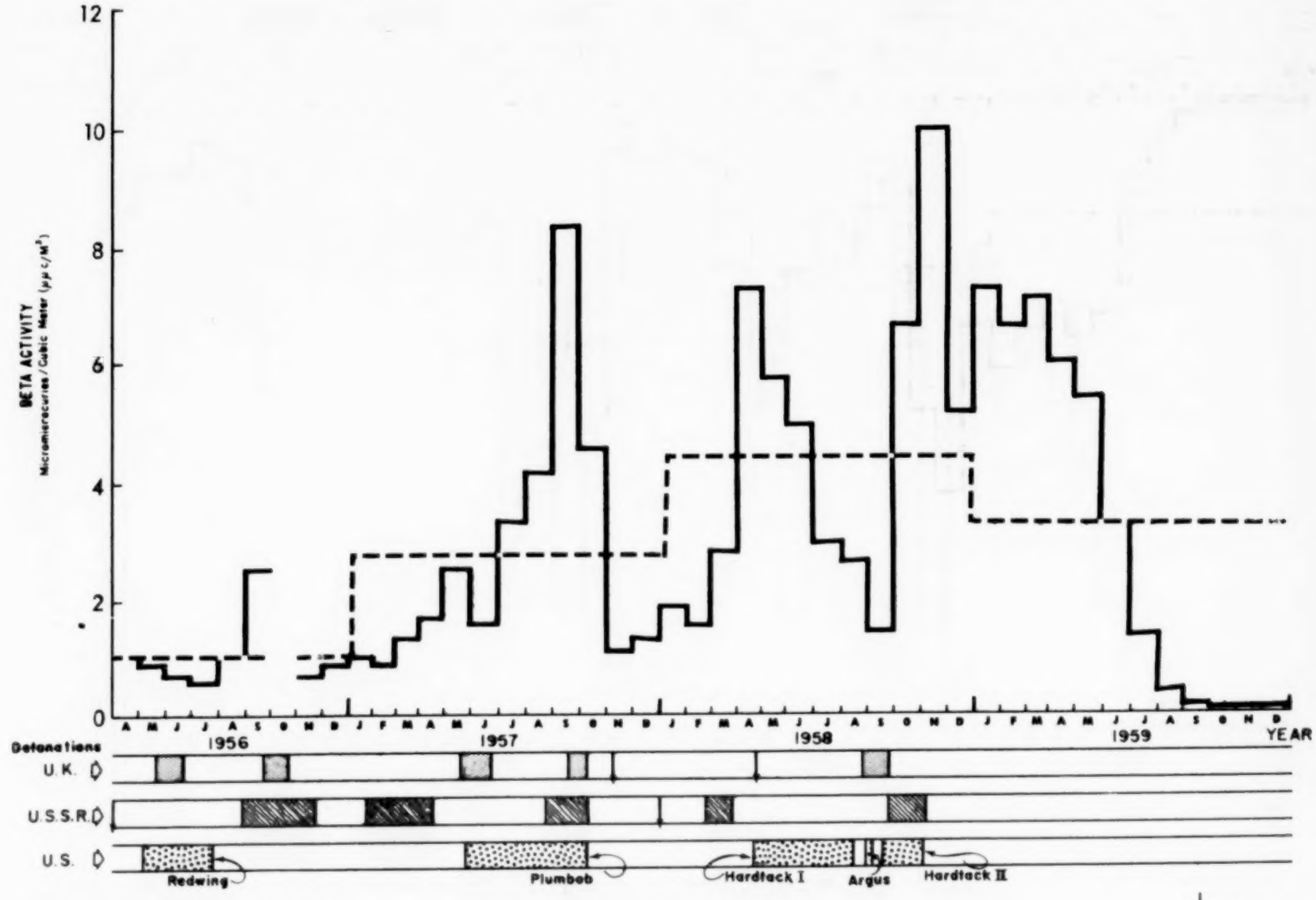


FIGURE 45

BETA ACTIVITY OF AIR-BORNE PARTICULATES
Minneapolis, Minnesota
Radiation Surveillance Network

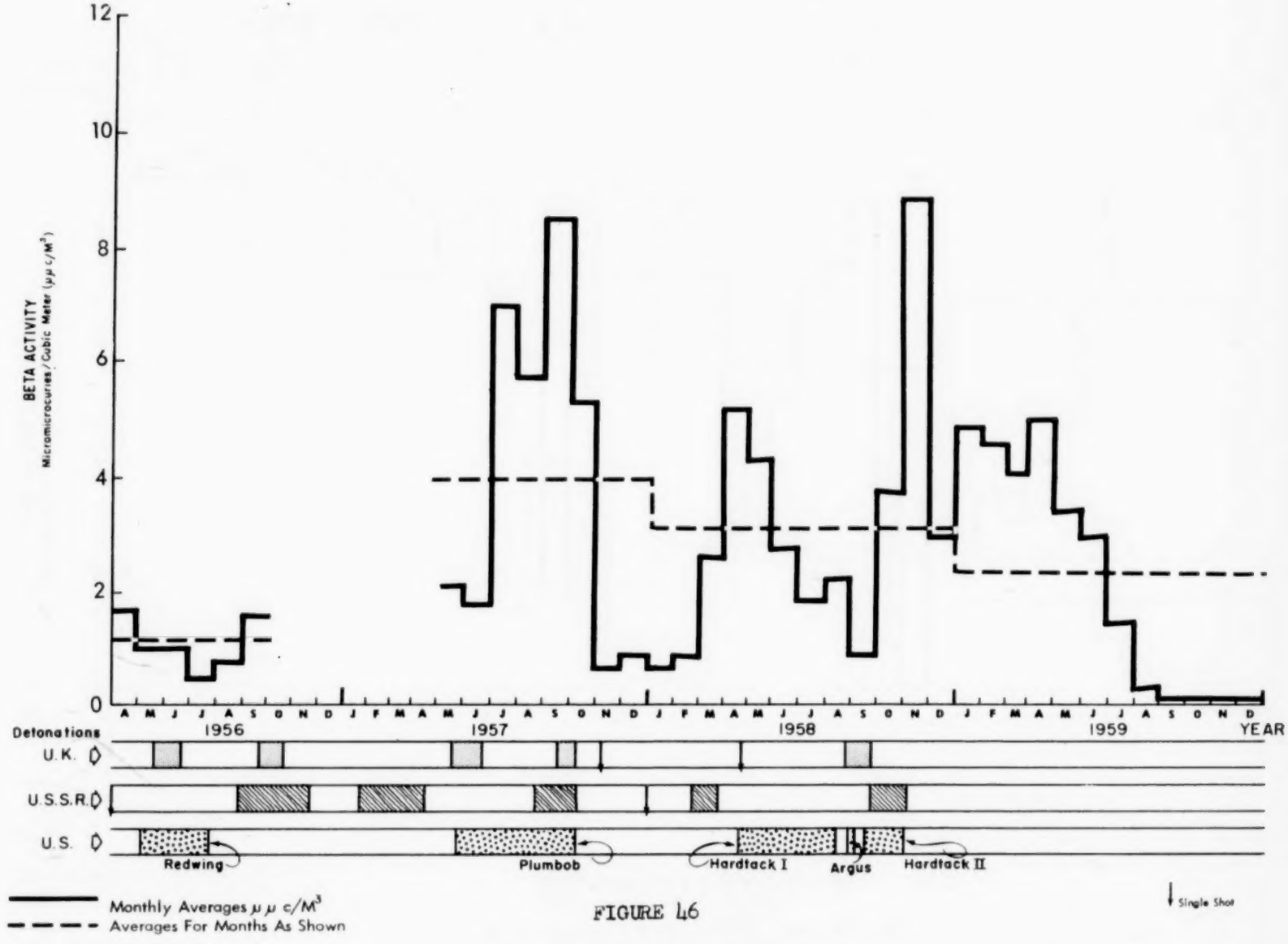


FIGURE 46

Averages For Months As Shown

BETA ACTIVITY OF AIR-BORNE PARTICULATES
Pascagoula, Mississippi
Radiation Surveillance Network

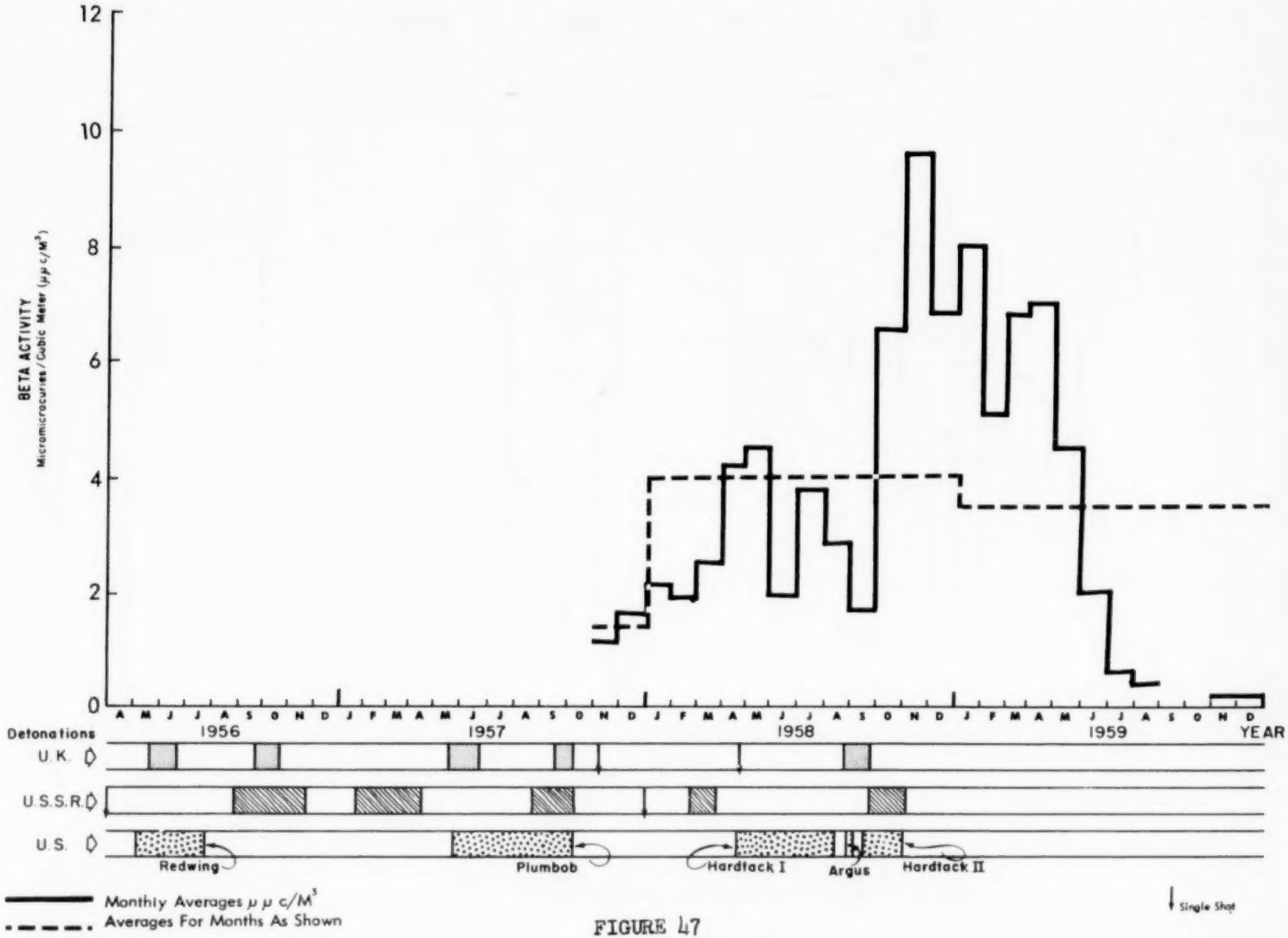


FIGURE 47

BETA ACTIVITY OF AIR-BORNE PARTICULATES
Jefferson City, Missouri
Radiation Surveillance Network

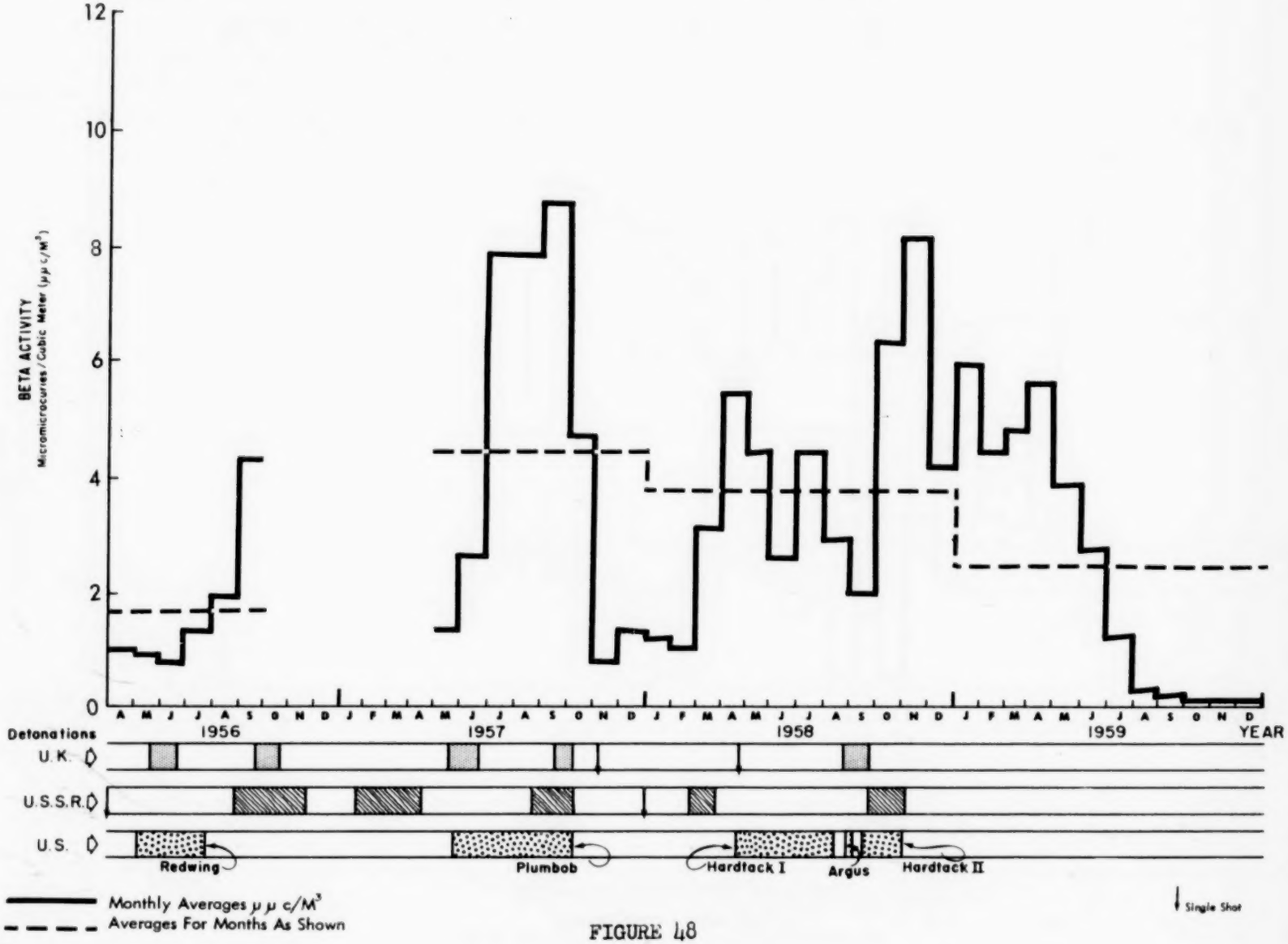


FIGURE 48

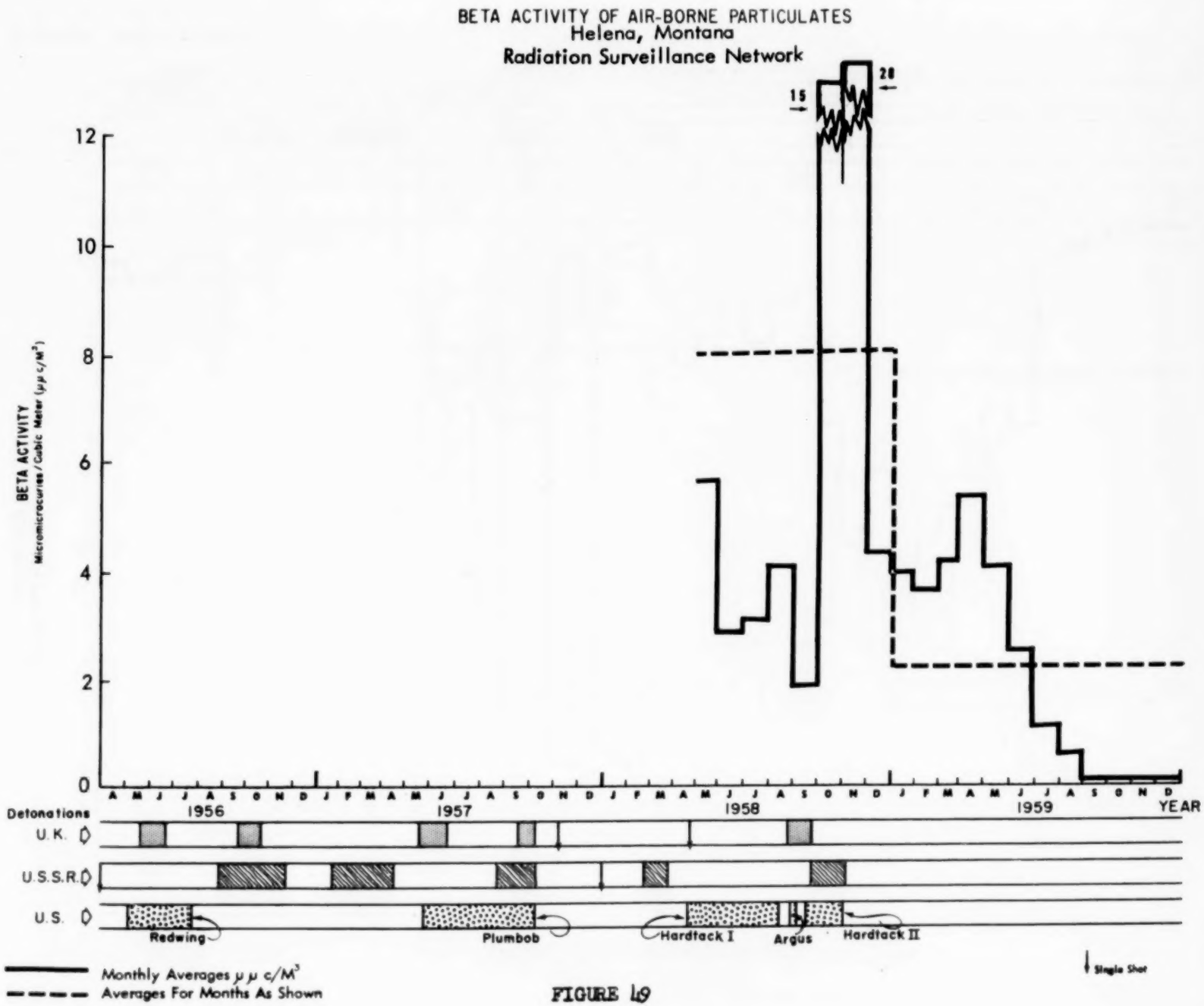

BETA ACTIVITY OF AIR-BORNE PARTICULATES
Helena, Montana
Radiation Surveillance Network
BETA ACTIVITY
Micromicrocuries / Cubic Meter (μμ c/M³)
15
20
12
10
8
6
4
2
0
A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1956
1957
1958
1959
YEAR
Detonations
U.K.
U.S.S.R.
U.S.
Redwing
Plumbob
Hardtack I
Argus
Hardtack II
Single Shot
Monthly Averages μμ c/M³
Averages For Months As Shown

FIGURE 19

BETA ACTIVITY OF AIR-BORNE PARTICULATES
Trenton, New Jersey
Radiation Surveillance Network

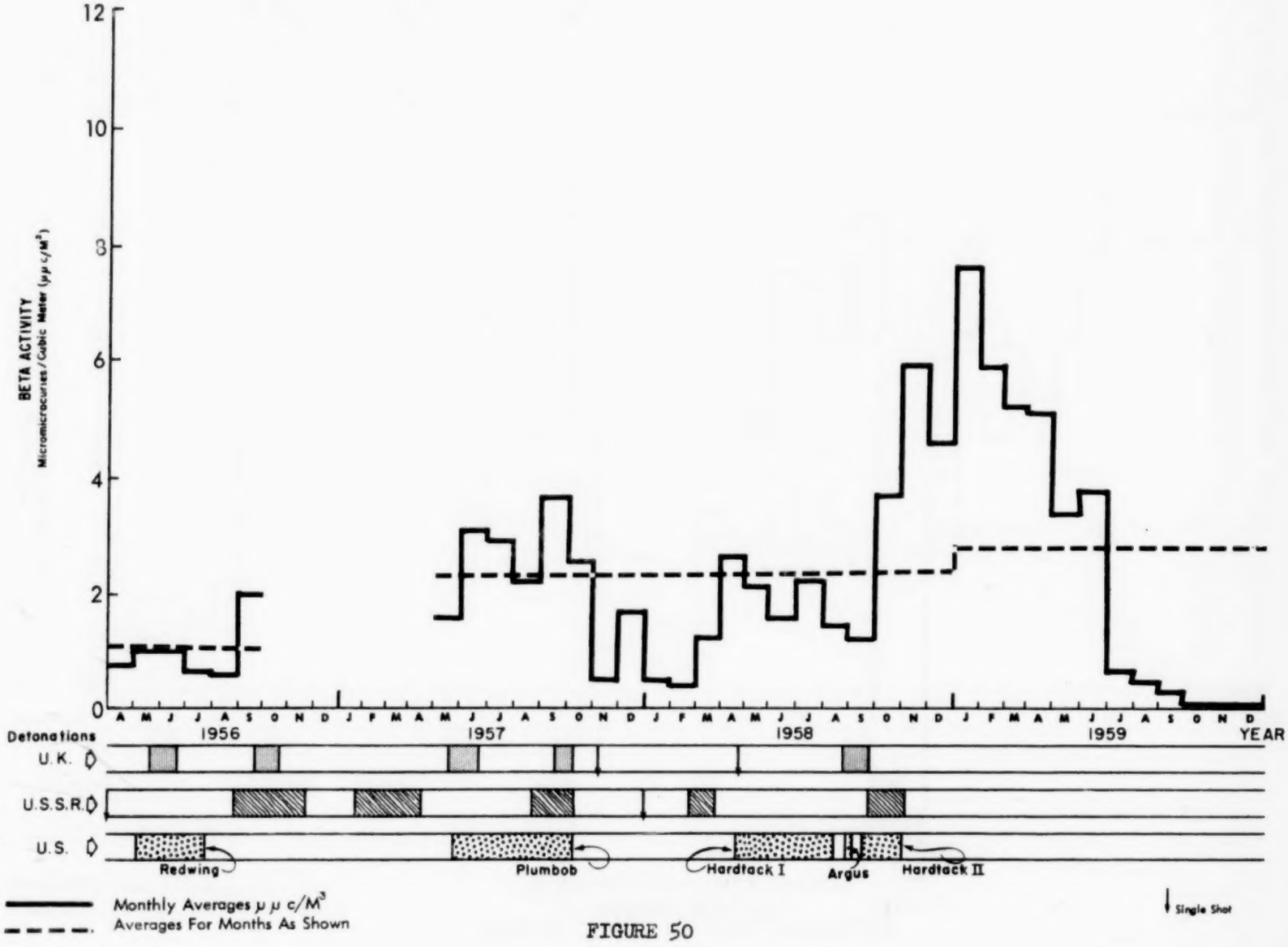


FIGURE 50

Averages For Months As Shown

FIGURE 50

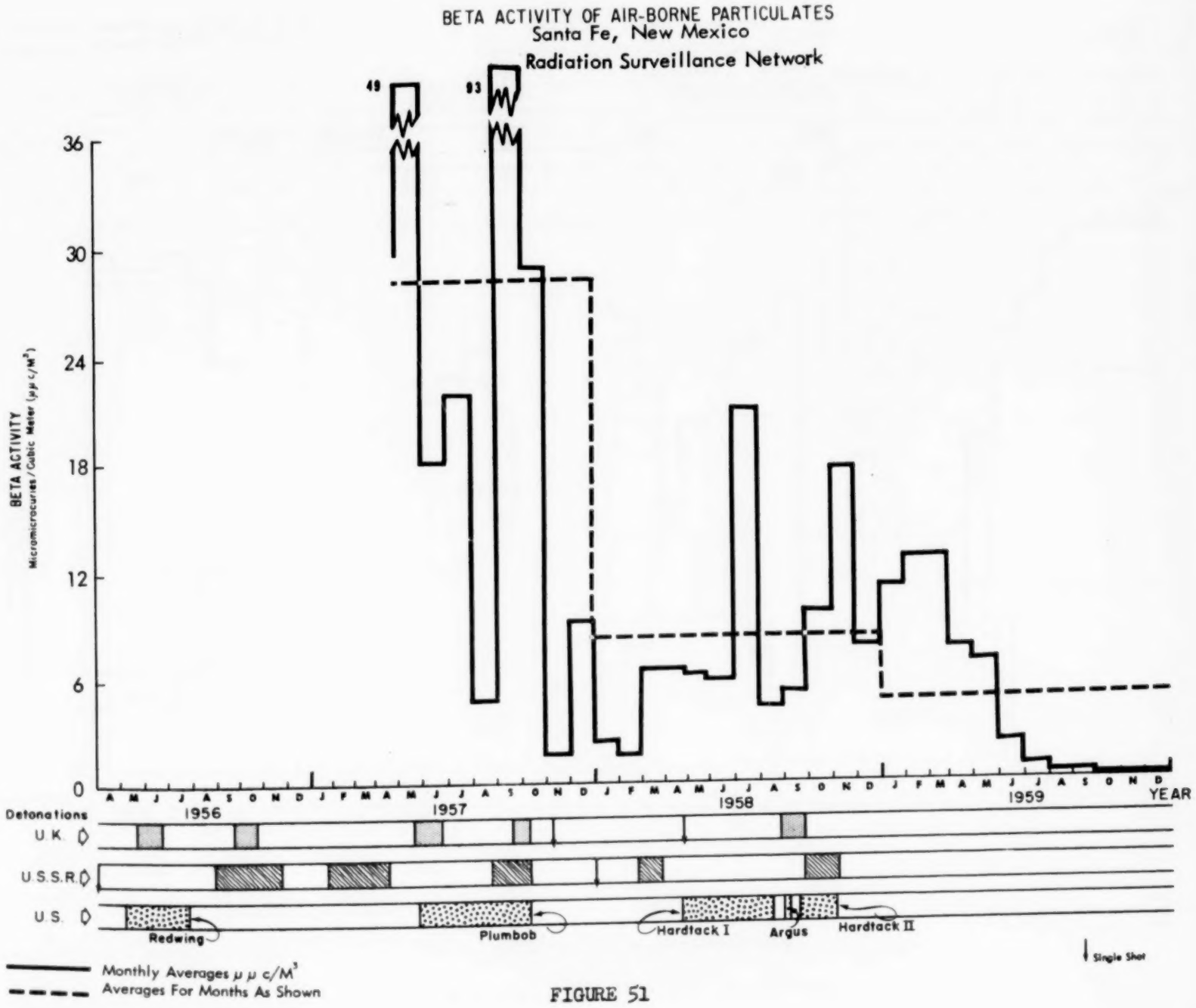


FIGURE 51

BETA ACTIVITY OF AIR-BORNE PARTICULATES
Albany, New York
Radiation Surveillance Network

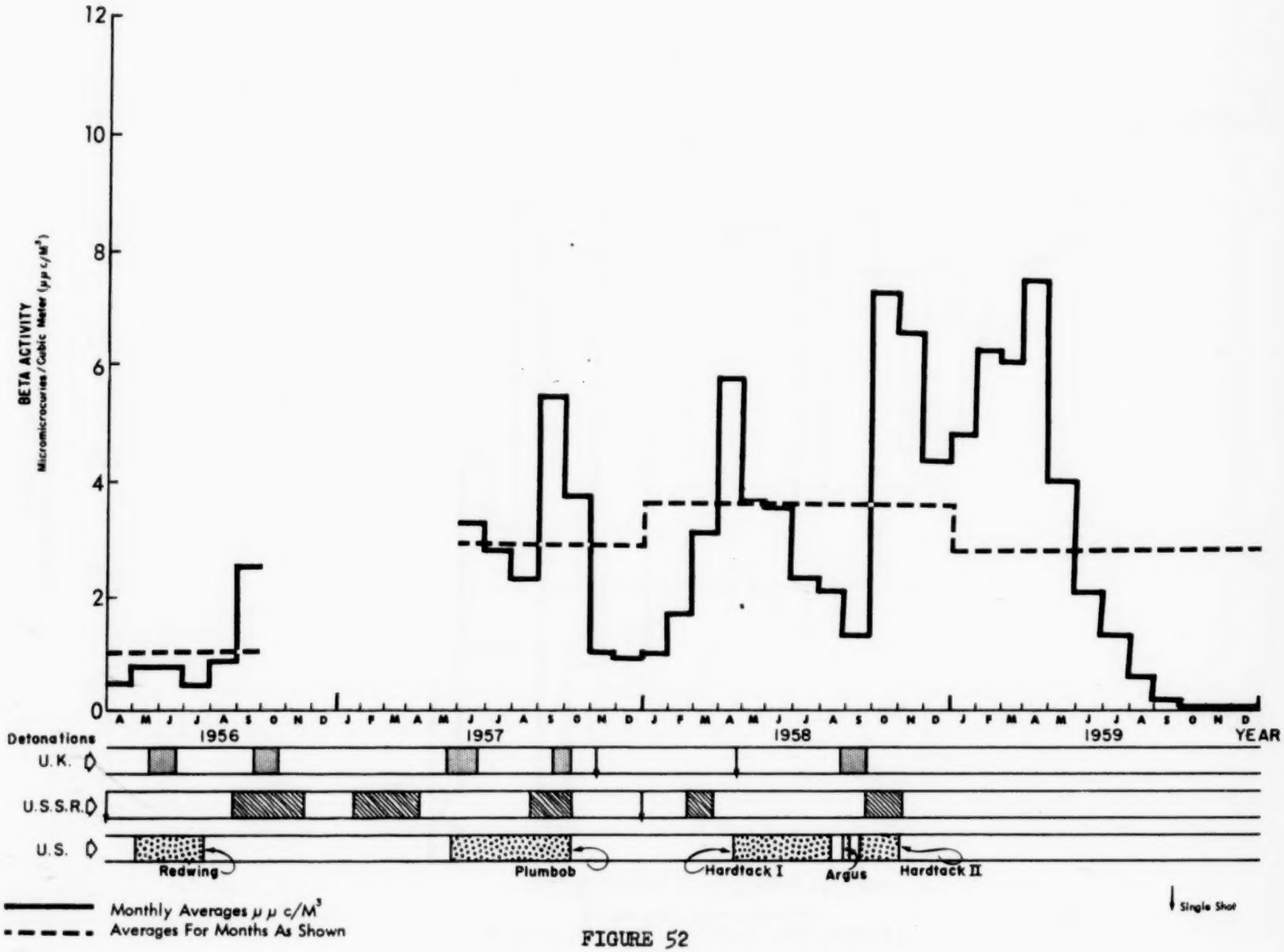


FIGURE 52

FIGURE 52

BETA ACTIVITY OF AIR-BORNE PARTICULATES
Gastonia, North Carolina
Radiation Surveillance Network

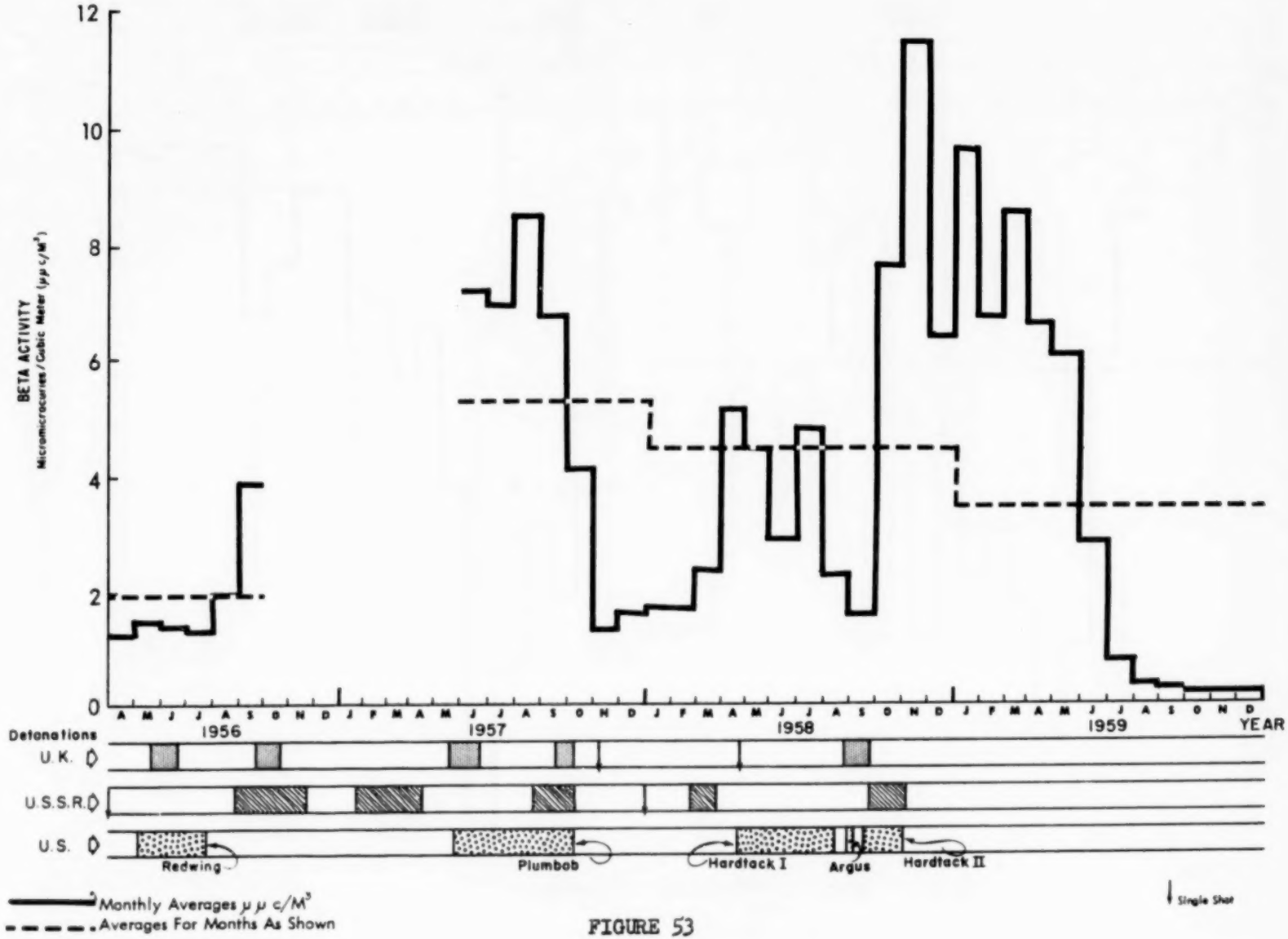


FIGURE 53

BETA ACTIVITY OF AIR-BORNE PARTICULATES
Cincinnati, Ohio
Radiation Surveillance Network

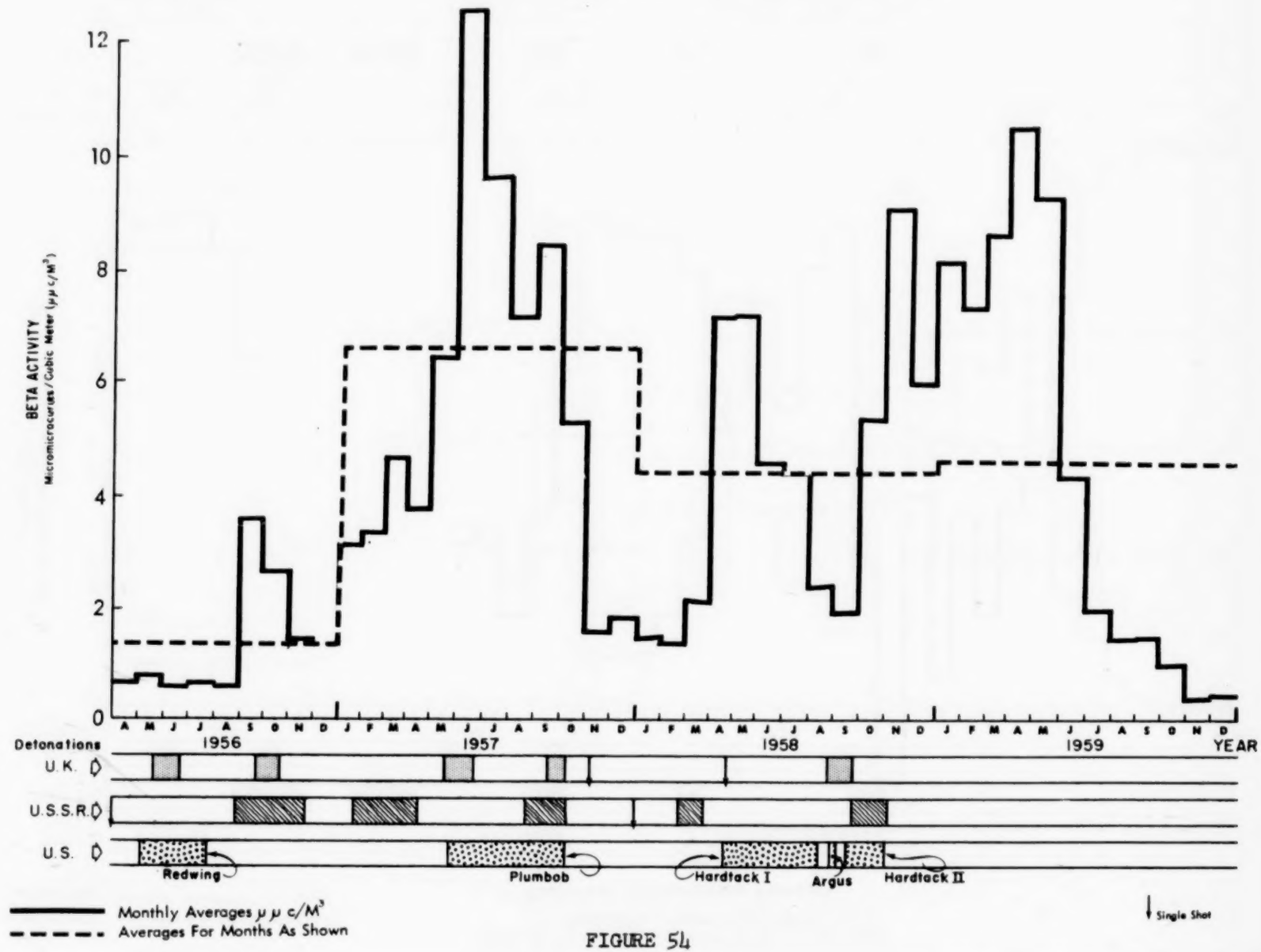


FIGURE 54

Averages For Months As Shown

FIGURE 54

BETA ACTIVITY OF AIR-BORNE PARTICULATES
Oklahoma City, Oklahoma
RADIATION SURVEILLANCE NETWORK

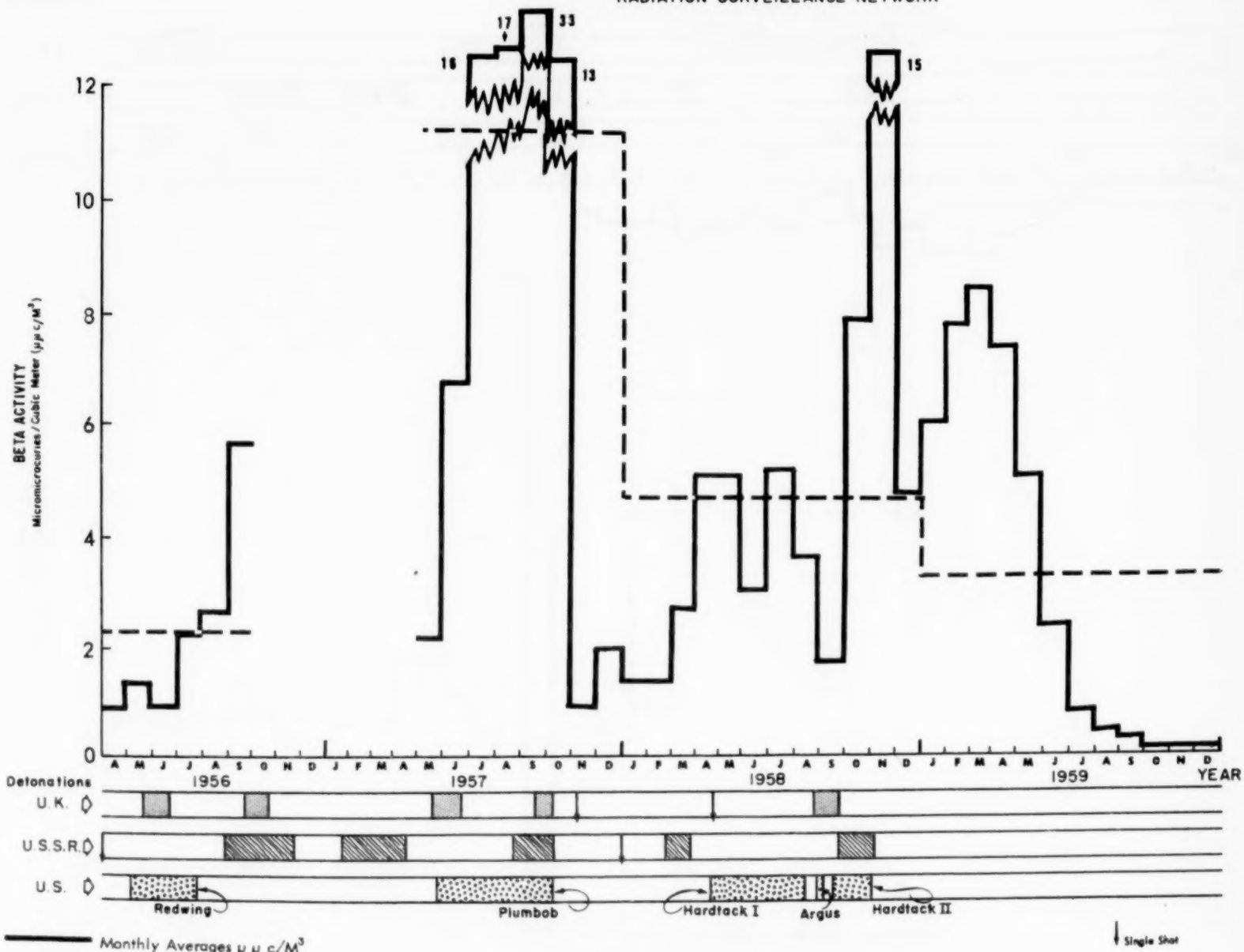


FIGURE 55

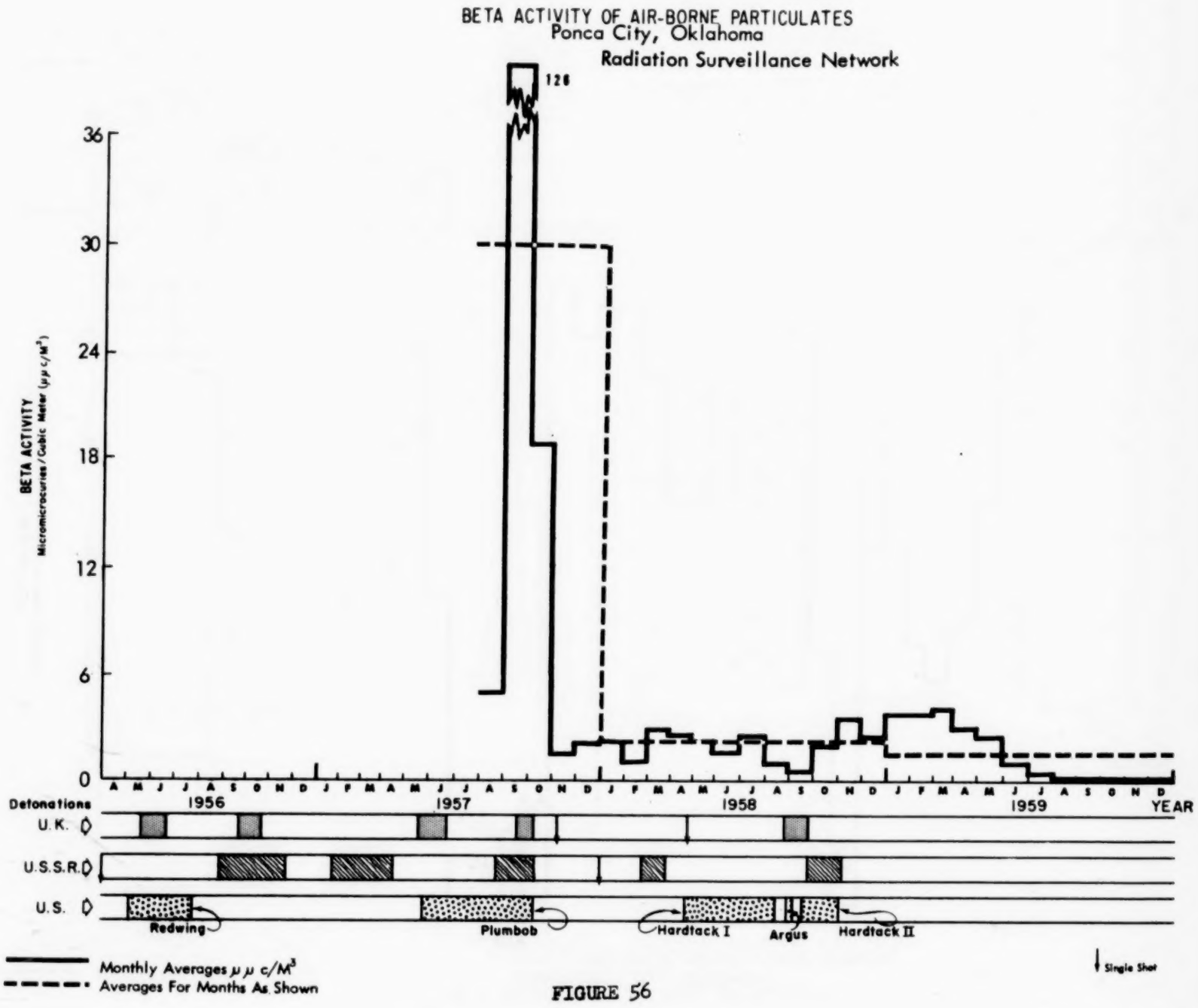

BETA ACTIVITY OF AIR-BORNE PARTICULATES
Ponca City, Oklahoma
Radiation Surveillance Network
128
36
30
24
18
12
6
0
BETA ACTIVITY
Micromicrocuries / Cubic Meter (μμc/M³)
A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1956
1957
1958
1959
YEAR
Detonations
U.K.
U.S.S.R.
U.S.
Redwing
Plumbob
Hardtack I
Argus
Hardtack II
Monthly Averages μμc/M³
Averages For Months As Shown
Single Shot

FIGURE 56

FIGURE 56

BETA ACTIVITY OF AIR-BORNE PARTICULATES
Portland, Oregon
Radiation Surveillance Network

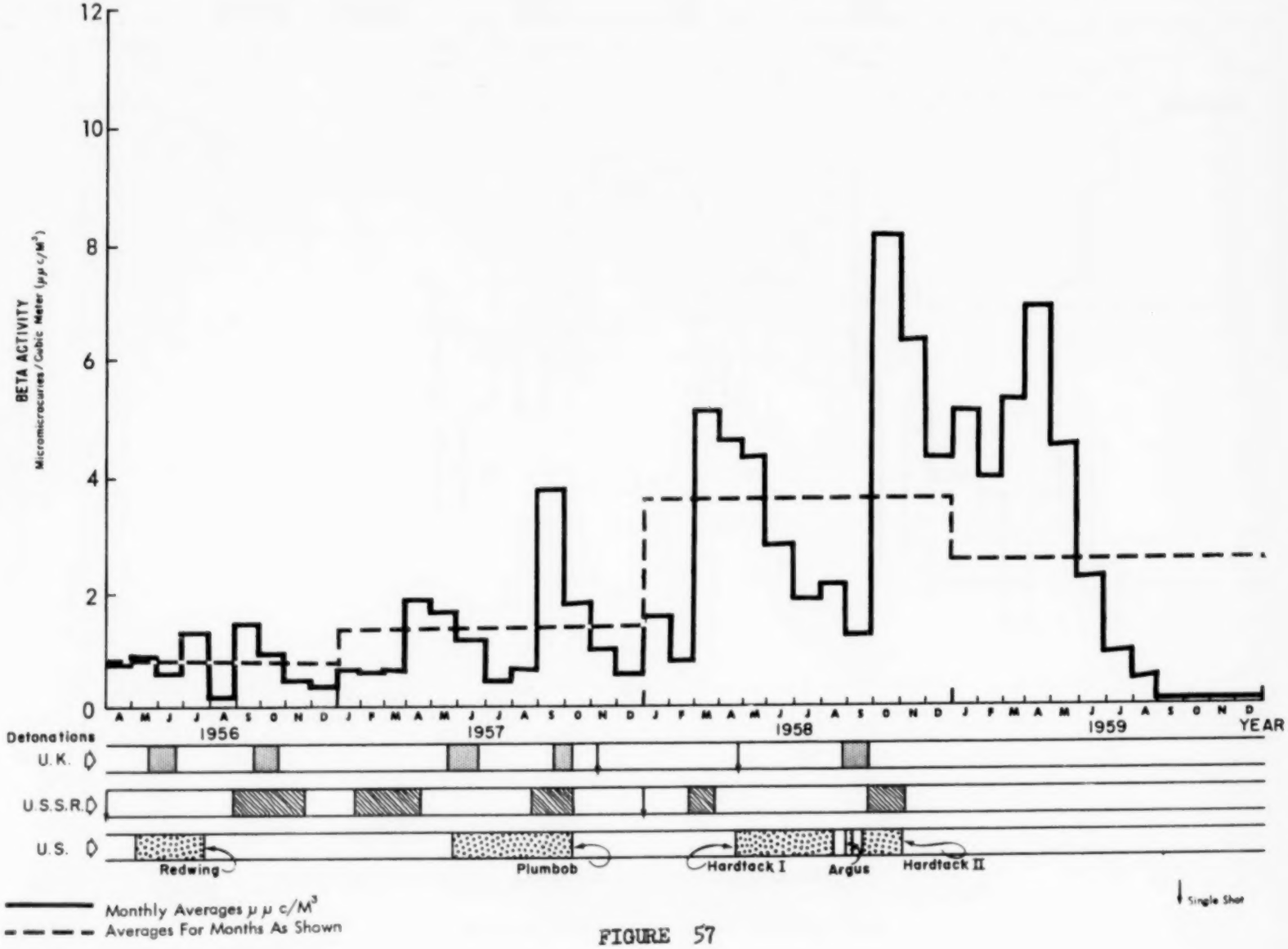


FIGURE 57

BETA ACTIVITY OF AIR-BORNE PARTICULATES
Harrisburg, Pennsylvania
Radiation Surveillance Network

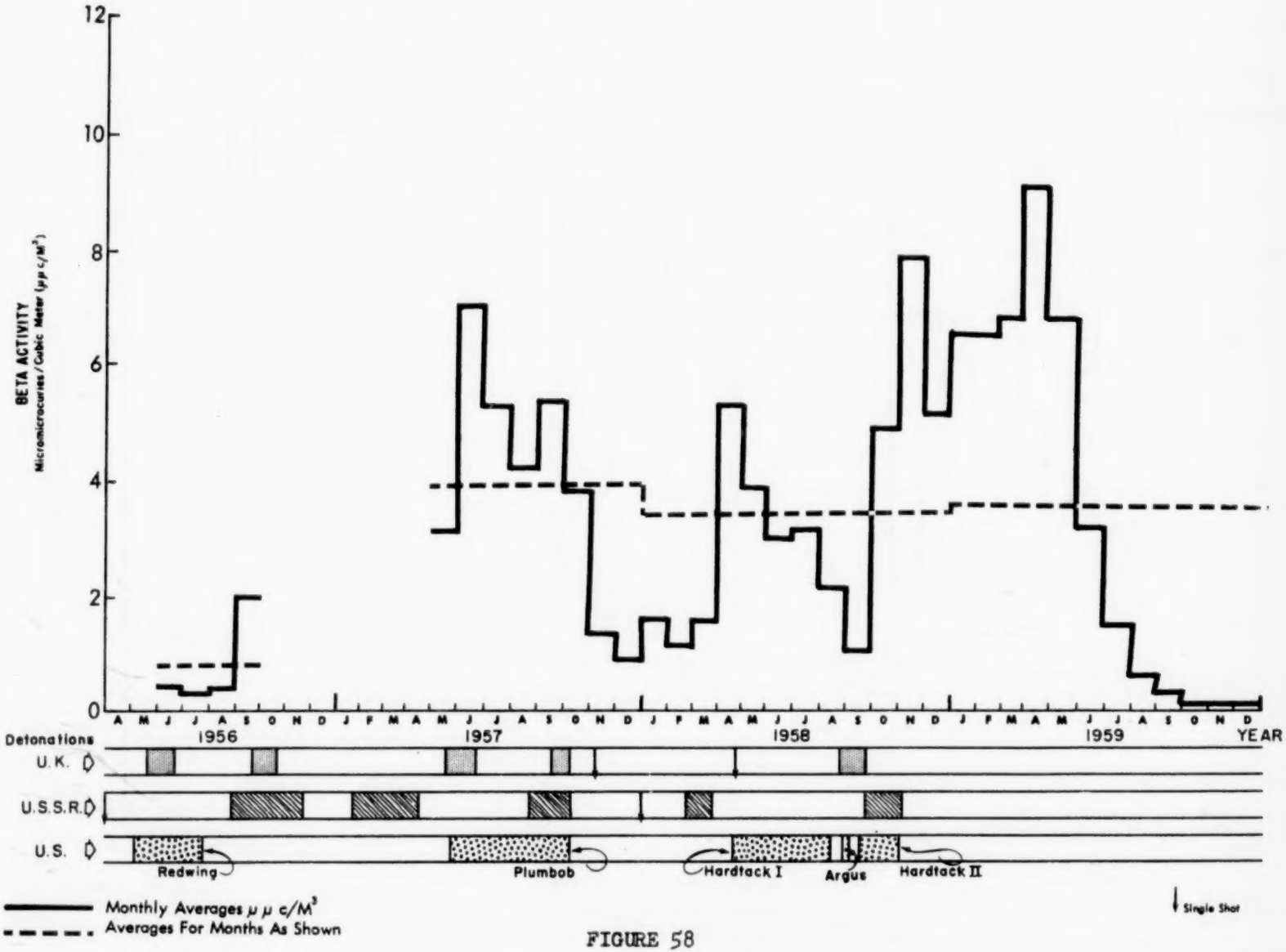


FIGURE 58

Averages For Months As Shown

FIGURE 58

BETA ACTIVITY OF AIR-BORNE PARTICULATES
Providence, Rhode Island
Radiation Surveillance Network

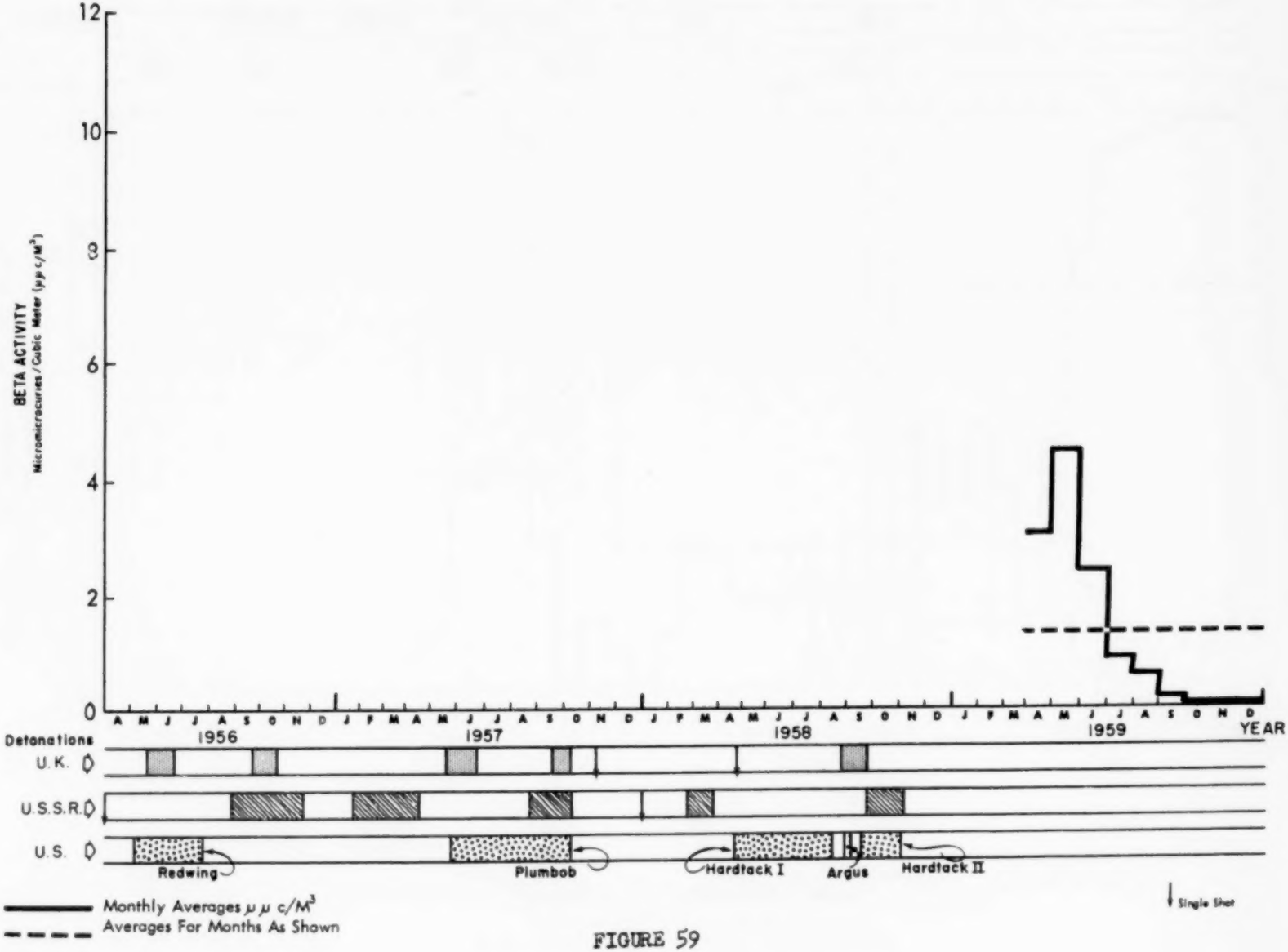


FIGURE 59

BETA ACTIVITY OF AIR-BORNE PARTICULATES
Columbia, South Carolina
Radiation Surveillance Network

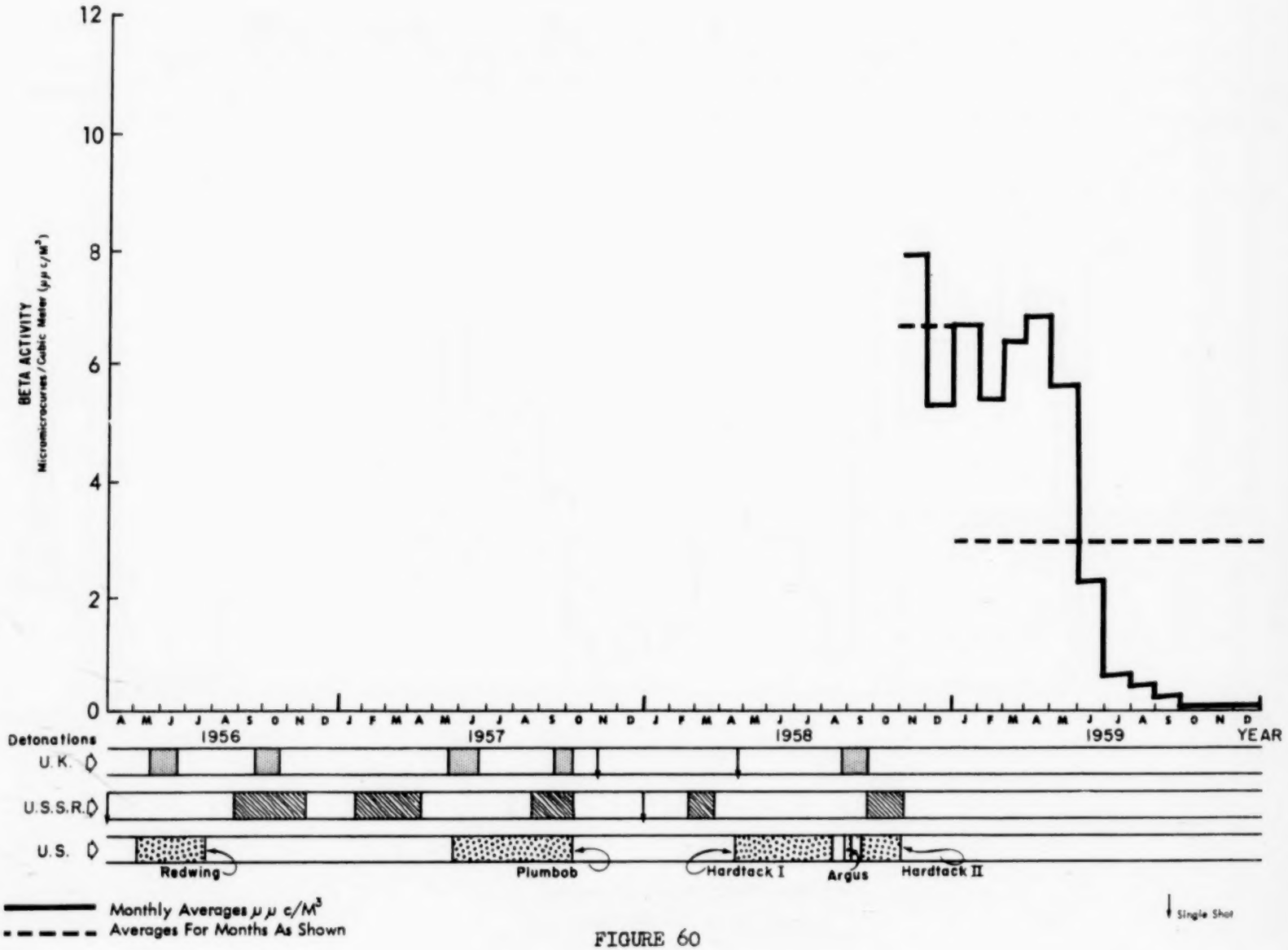


FIGURE 60

FIGURE 60

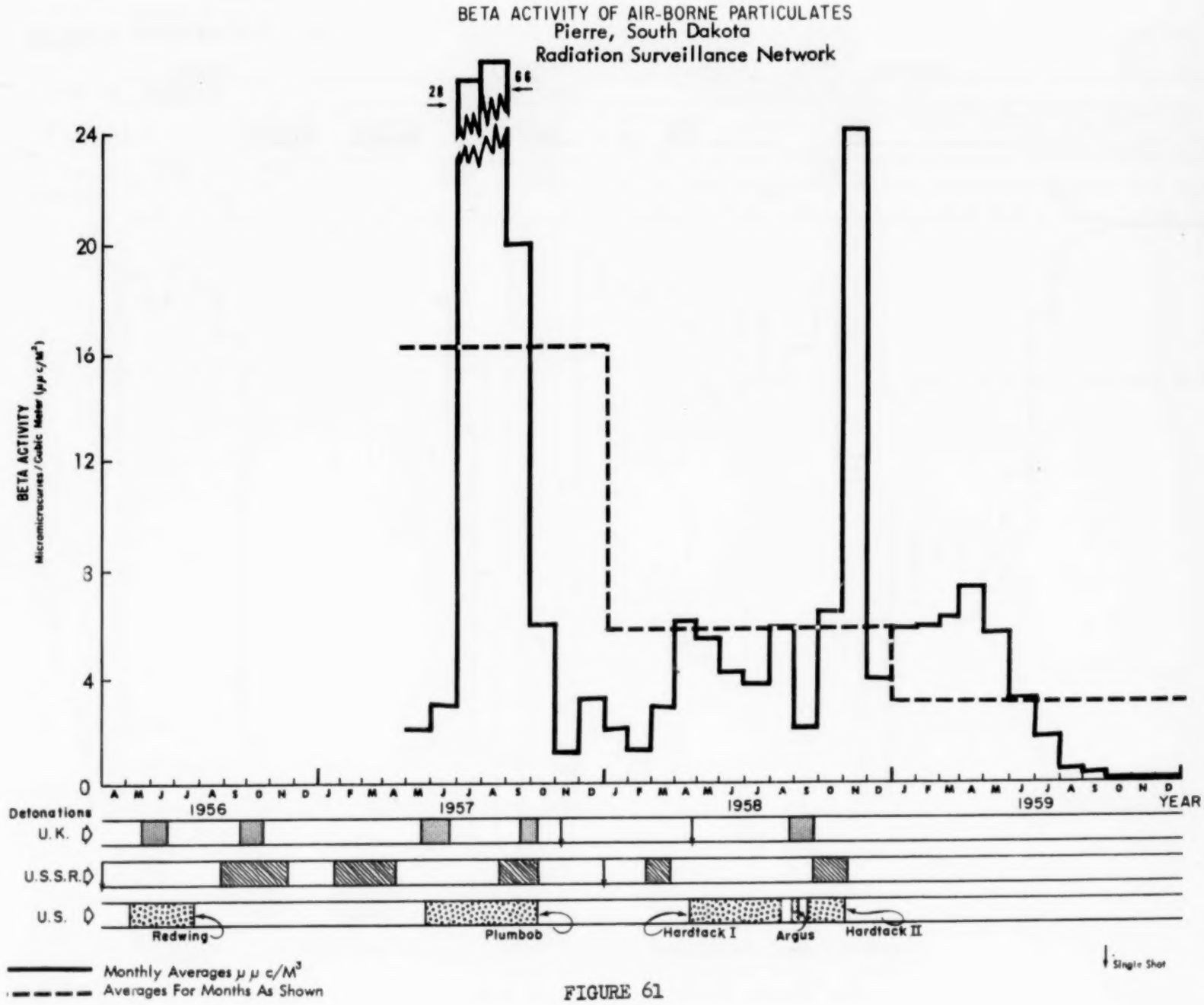


FIGURE 61

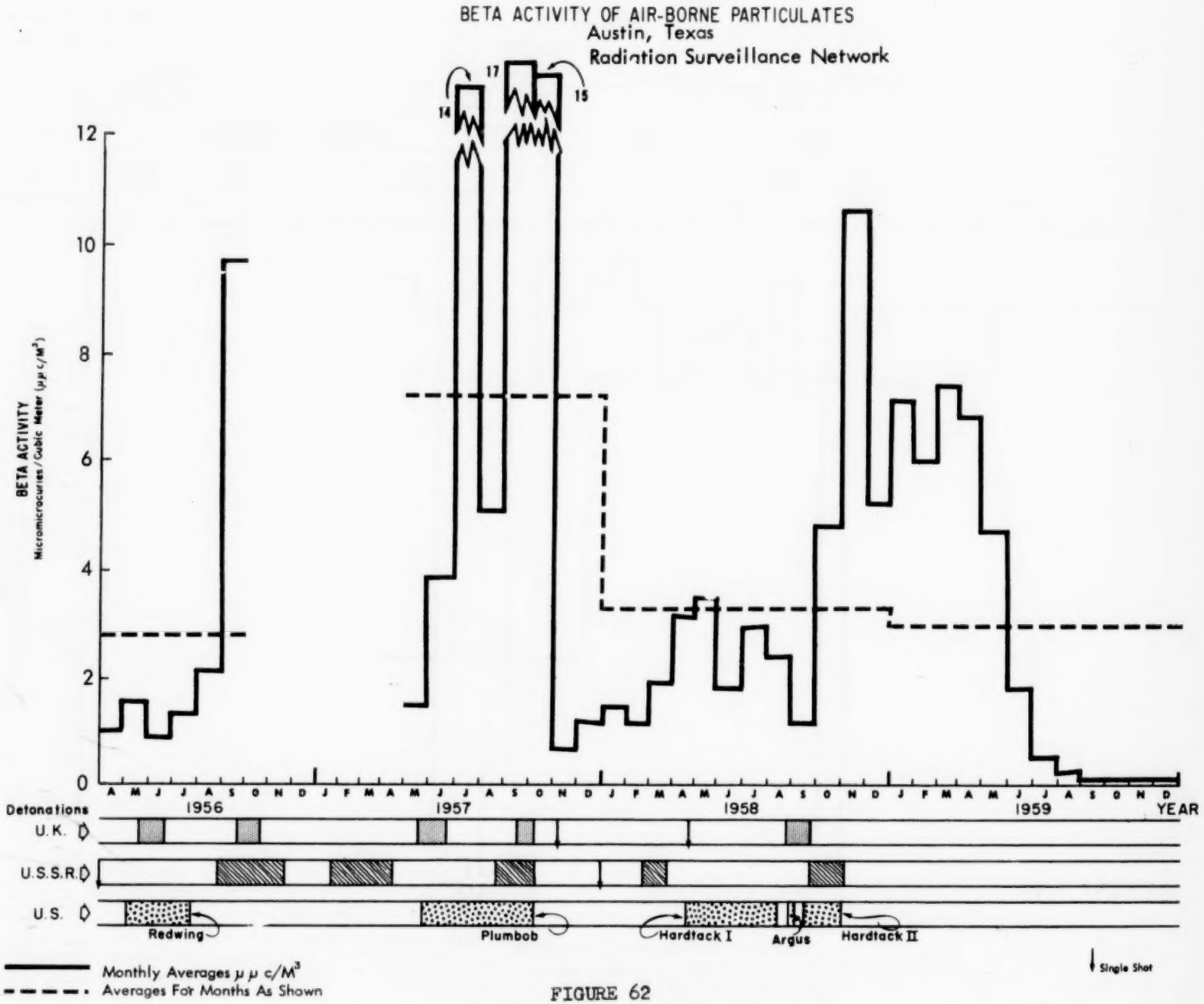

BETA ACTIVITY OF AIR-BORNE PARTICULATES
Austin, Texas
Radiation Surveillance Network
14
17
15
BETA ACTIVITY
Micromicrocuries / Cubic Meter (μμc/M³)
12
10
8
6
4
2
0
A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1956
1957
1958
1959
YEAR
Detonations
U.K.
U.S.S.R.
U.S.
Redwing
Plumbob
Hardtack I
Argus
Hardtack II
Single Shot
Monthly Averages μμc/M³
Averages For Months As Shown

FIGURE 62

Averages For Months As Shown

FIGURE 62

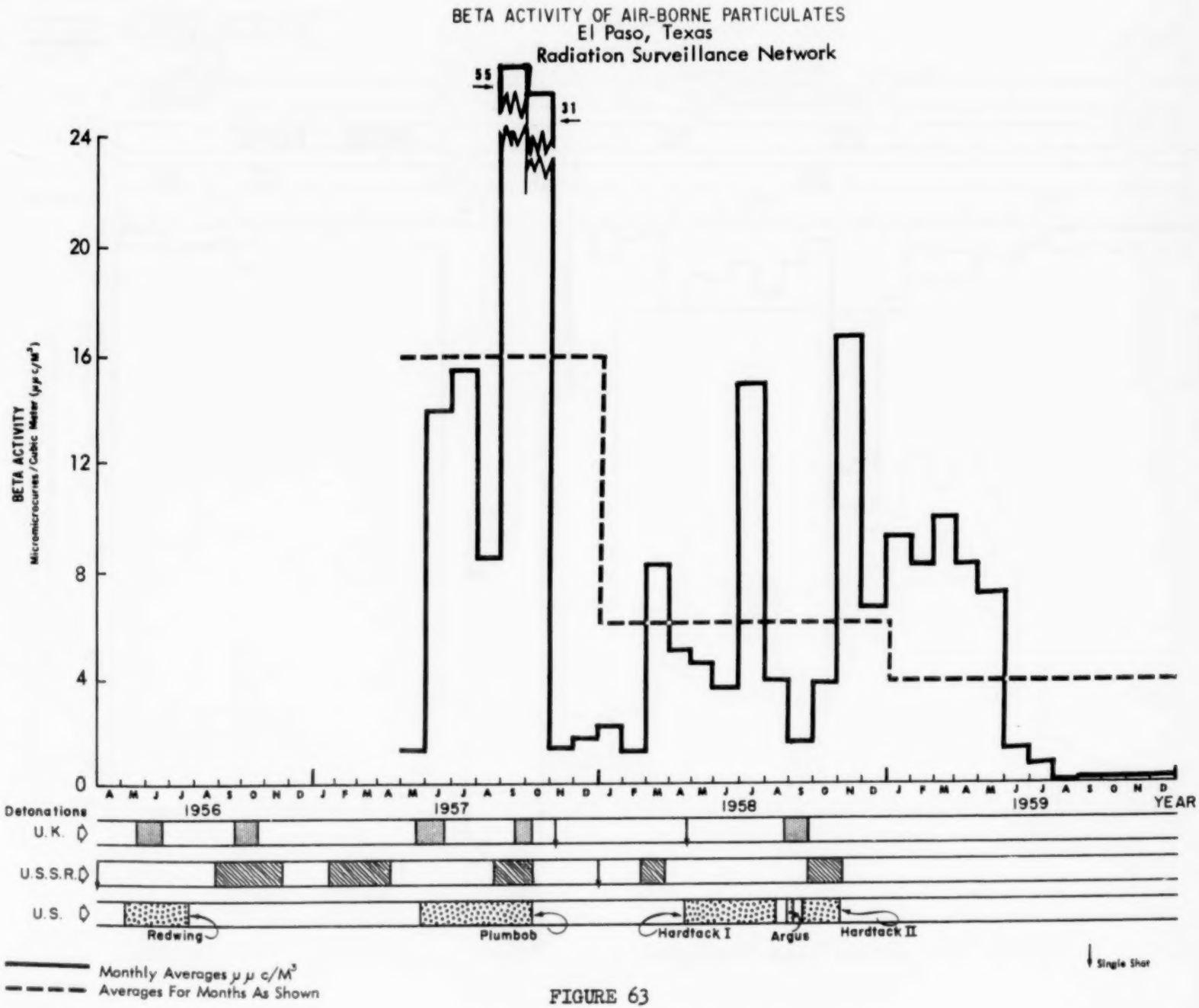


FIGURE 63

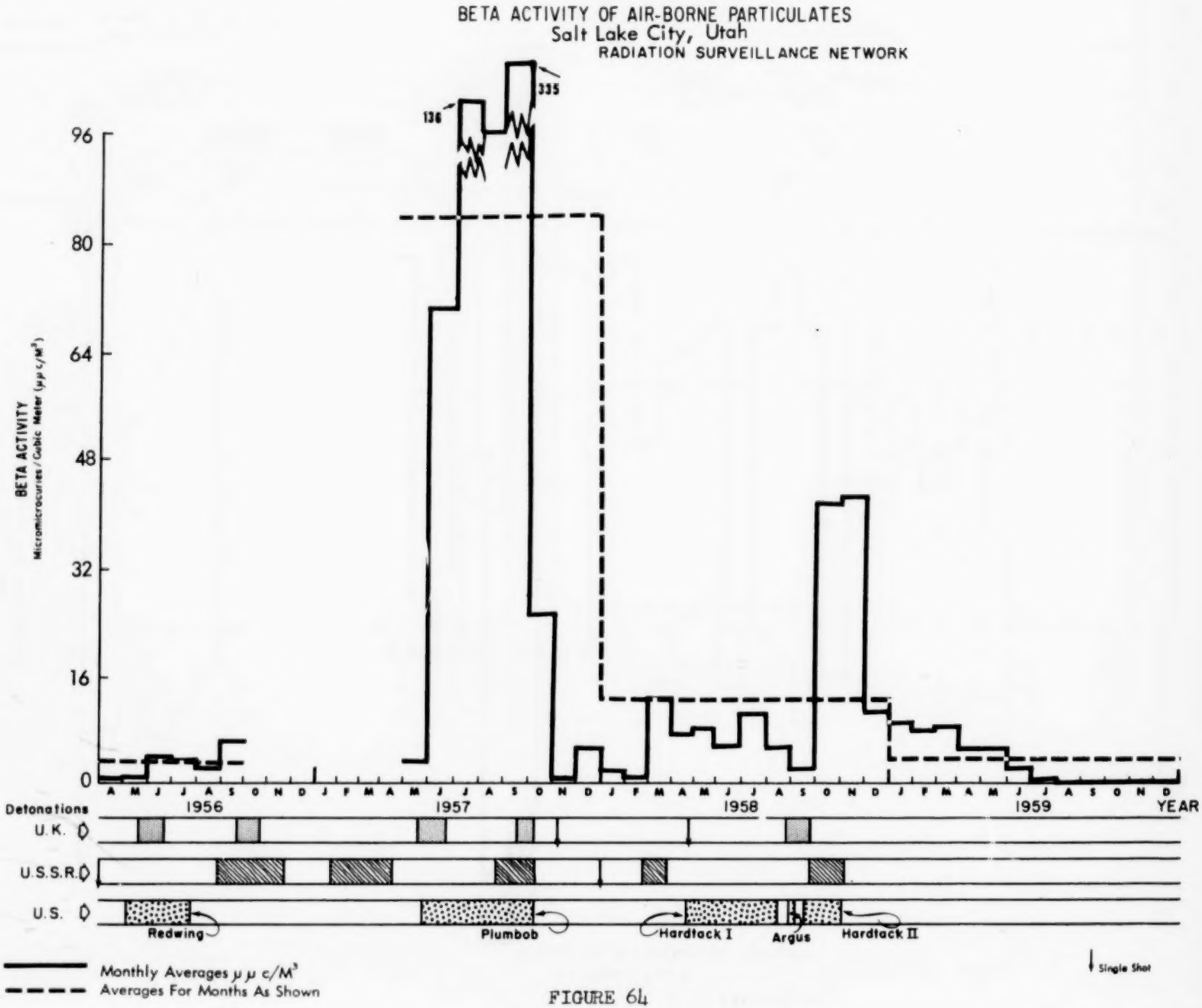


FIGURE 64

BETA ACTIVITY OF AIR-BORNE PARTICULATES

Averages For Months As Shown

FIGURE 64

BETA ACTIVITY OF AIR-BORNE PARTICULATES
Richmond, Virginia
Radiation Surveillance Network

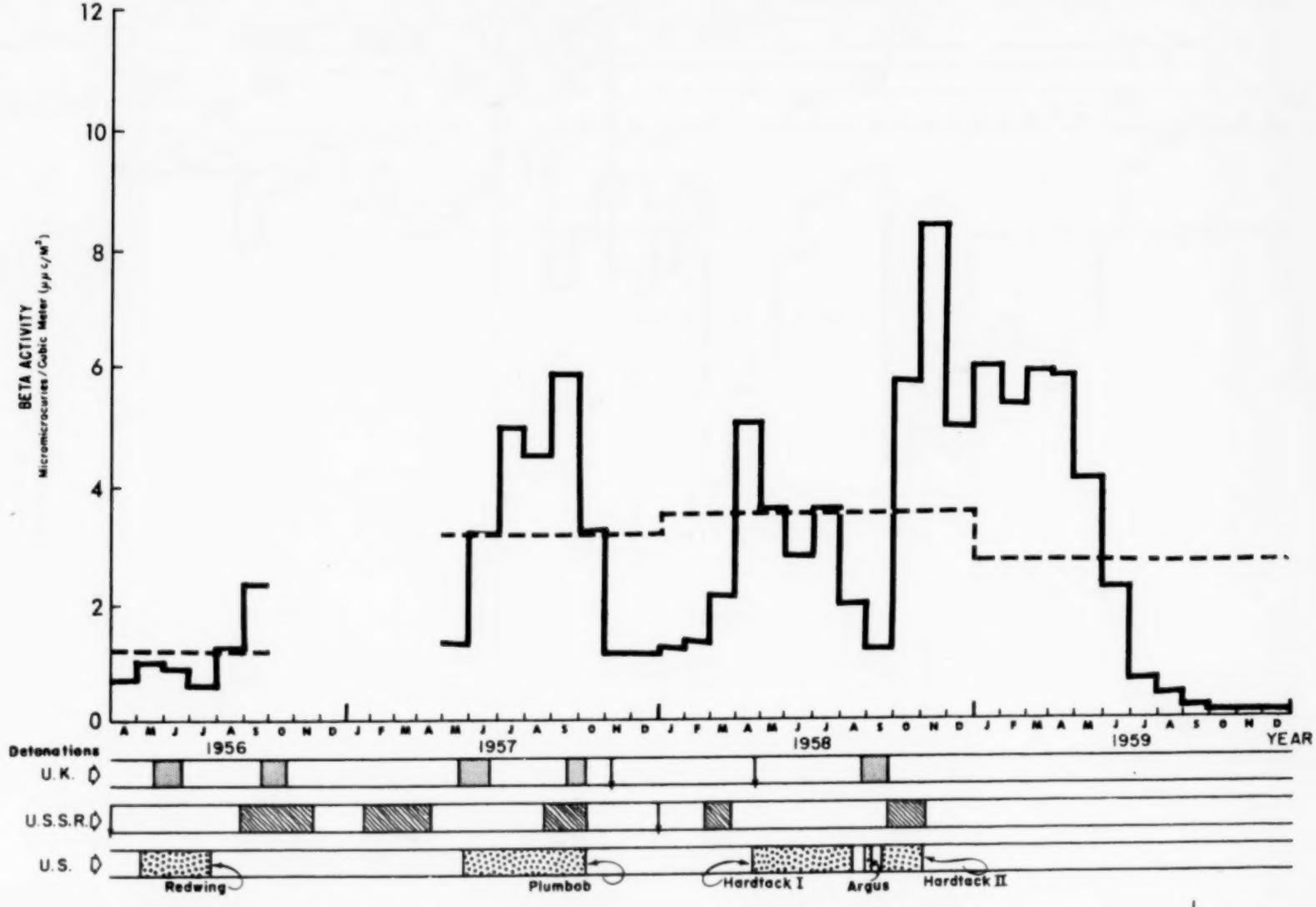


FIGURE 65

BETA ACTIVITY OF AIR-BORNE PARTICULATES
Seattle, Washington
Radiation Surveillance Network

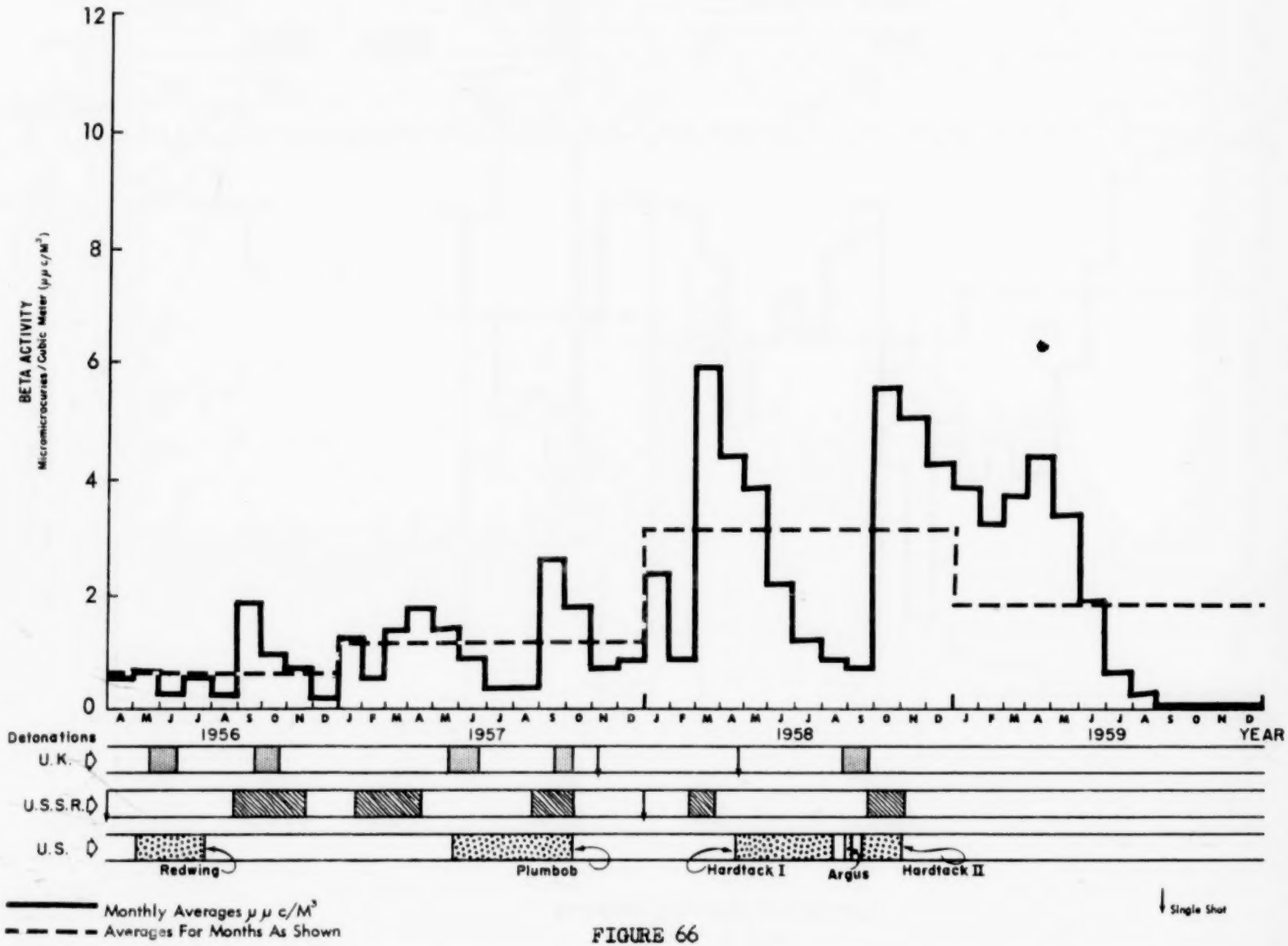


FIGURE 66

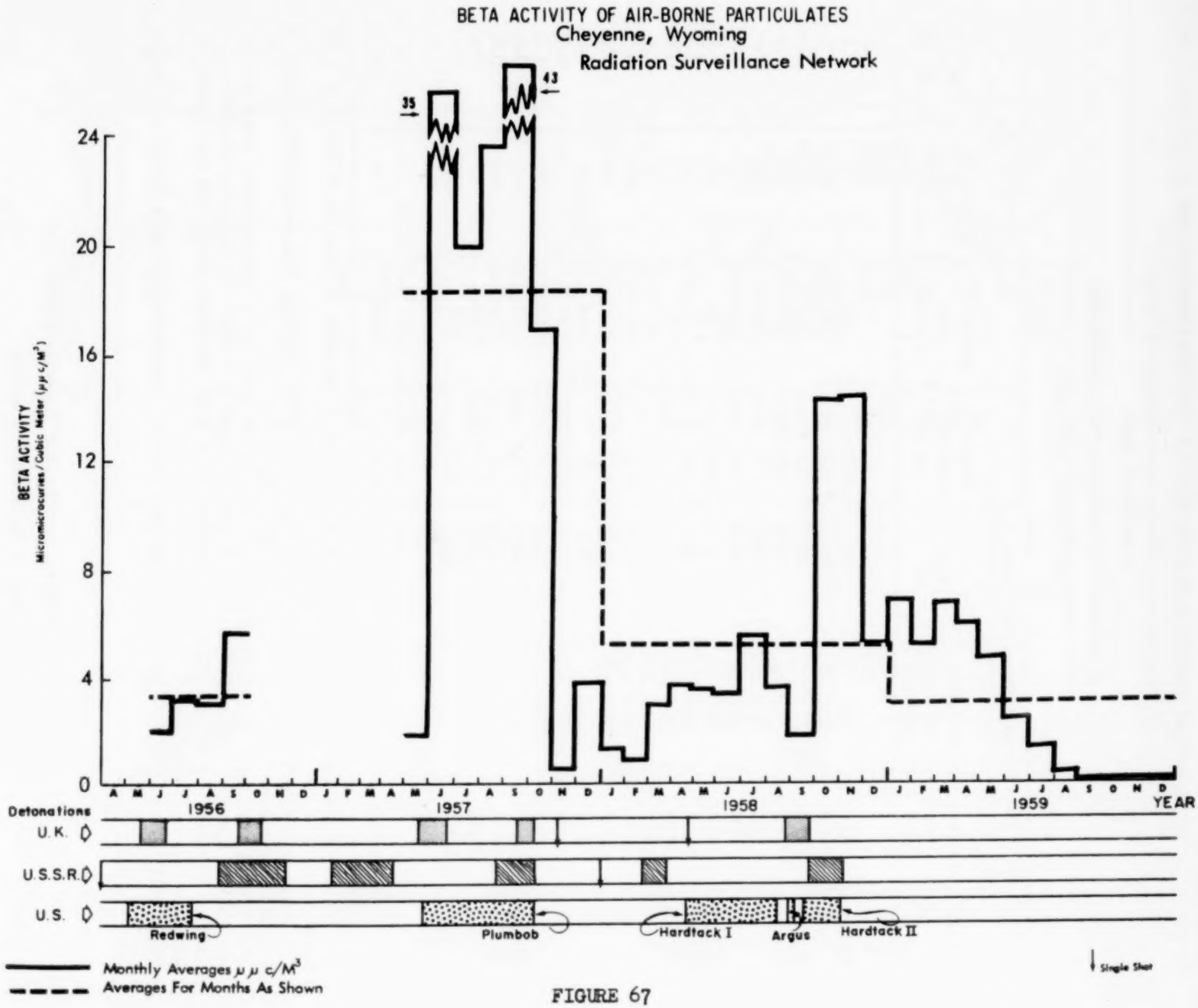

BETA ACTIVITY OF AIR-BORNE PARTICULATES
Cheyenne, Wyoming
Radiation Surveillance Network
35
43
24
20
16
12
8
4
0
BETA ACTIVITY
Micromicrocuries / Cubic Meter (μμ c/M³)
A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1956
1957
1958
1959
YEAR
Detonations
U.K.
U.S.S.R.
U.S.
Redwing
Plumbob
Hardtack I
Argus
Hardtack II
Monthly Averages μμ c/M³
Averages For Months As Shown
Single Shot

FIGURE 67

TABLE VII.—RADON AND THORON AIR MEASUREMENTS

February 2, 1960 through February 29, 1960
Cincinnati, Ohio

RADIATION SURVEILLANCE NETWORK

(Beta Activity Included)

Date	Continuous Sample Collection			Beta [a] activity $\mu\mu c/M^3$	Radon [b] AM $\mu\mu c/M^3$	Radon [c] PM $\mu\mu c/M^3$	Thoron [d] $\mu\mu c/M^3$
	Sample change time	Sampling period (hours)	Volume M^3				
Feb. 2	0804	22.9	30.1	0.7	115	71	1.8
3	0808	23.9	30.7	0.4	161	110	1.1
4	0804	23.9	30.7	0.6	221	141	1.6
5	0808	23.9	30.8	0.2 (3)	153	89	1.9
8	0802	71.8	92.6	0.2	142	129	1.3
9	0804	24.0	31.5	0.5	226	173	1.6
10	0804	24.0	31.4	0.5	54	39	0.9
11	0806	24.0	30.1	0.2	76	48	0.3
12	0808	24.0	31.8	0.5 (3)	51	55	0.6
15	0808	72.0	91.2	0.2	345	46	0.8
16	0806	23.9	30.5	0.3	171	199	0.7
17	0806	23.9	31.0	0.3	101	85	0.6
18	0818	24.1	30.5	0.4	160	120	1.0
19	0804	23.7	31.1	0.09 (4)	129	55	0.5
23	0806	95.9	120.3	0.4	413	132	1.7
24	0806	23.9	30.0	0.4	192	125	0.9
25	0804	23.9	30.7	0.2	176	166	0.3
26	0806	23.9	29.5	0.09 (3)	63	53	0.2
29	0806	71.8	83.6	0.09	99	72	0.4
	Average.....			0.3	160	100	0.95

[a] Gross beta activity when counted one day after end of sampling or later as indicated by numeral in parenthesis.

[b] Measured within a few minutes of removal of filter from sampler and corrected back to collection time (uncorrected for thoron daughter interference).

[c] Filters are temporarily withdrawn from sampler at about 3 p.m. and counted. (Values are corrected back to removal time.) The filters are then replaced on sampler to complete the sampling period of about 24 hours. Thus, the values in this column are from the same filters that are counted at about 8 a.m. the following day.

[d] Thoron from alpha activity of filter sample counted 7 hours after taking a 24-96 hour sample.

U. S. NAVAL RESEARCH LABORATORY

Data on Radioactivity in Air

Radioactivity measurements of air-filter samples collected at various sites along the 80th Meridian (West) are made by the U. S. Naval Research Laboratory under a program partially financed by the Atomic Energy Commission.

The daily record of fission product beta activity during March 1960 is shown in Table VIII and the radioactivity profile for the same month is shown in Figure 68. All radioactivity concentrations are given in disintegrations per minute per cubic meter of air at the collecting site. (2.2 disintegrations per minute equals 1 micromicrocurie)

Increases in values recorded in February and March reflect the results of a nuclear detonation in the Sahara Desert February 13, 1960.

TABLE VIII.—U. S. NAVAL RESEARCH LABORATORY DAILY RECORD OF FISSION PRODUCT β-ACTIVITY COLLECTED BY AIR FILTRATION

March 1960

Disintegrations/minute per cubic meter of air							
Day	Punta Arenas	Puerto Montt	Santiago	Antofagasta	Chacaltaya	Lima	Guayaquil
1	0.05	0.17	0.14	0.12	0.09	0.03	0.32
2	0.05	0.17	0.14	0.12	0.09	0.03	1.10
3	0.05	0.15	0.13	0.11	0.08	0.06	1.22
4	0.05	0.15	0.13	0.11	0.08	0.06	1.56
5	0.02	0.10	0.14	0.09	0.07	0.01	1.56
6	0.02	0.10	0.14	0.09	0.07	0.01	1.52
7	0.02	0.10	0.06	0.09	0.07	0.01	1.52
8	-	0.13	0.06	0.09	0.05	0.08	1.08
9	-	0.13	0.06	0.09	0.05	0.08	0.85
10	-	0.05	0.12	0.09	0.05	0.05	0.46
11	-	0.05	0.12	0.09	0.05	0.05	0.41
12	-	0.07	0.12	0.14	0.06	0.08	0.39
13	-	0.07	0.12	0.14	0.06	0.08	0.24
14	-	0.07	0.12	0.14	0.06	0.08	0.24
15	-	0.09	0.14	0.13	0.08	0.05	-
16	-	0.09	0.14	0.13	0.08	0.05	-
17	-	0.12	0.14	0.14	0.06	-	-
18	-	0.12	0.14	0.14	0.06	-	-
19	-	0.07	0.12	0.12	0.06	-	-
20	-	0.07	0.12	0.12	0.06	-	-
21	-	0.07	0.12	0.12	0.06	-	-
22	-	0.07	0.18	0.13	0.05	-	0.14
23	-	0.12	0.18	0.13	0.05	-	0.16
24	-	0.09	0.18	0.13	0.04	-	0.20
25	-	0.09	0.18	0.13	0.04	-	0.18
26	-	-	0.09	0.13	0.02	-	0.14
27	-	-	0.09	0.13	0.02	-	0.14
28	-	-	0.09	0.13	0.02	-	0.14
29	-	-	0.12	0.11	0.04	-	-
30	-	-	0.12	0.11	0.04	-	-
31	-	-	0.20	0.13	0.01	-	-
Mean value	-	0.10	0.13	0.12	0.06	0.05	0.65

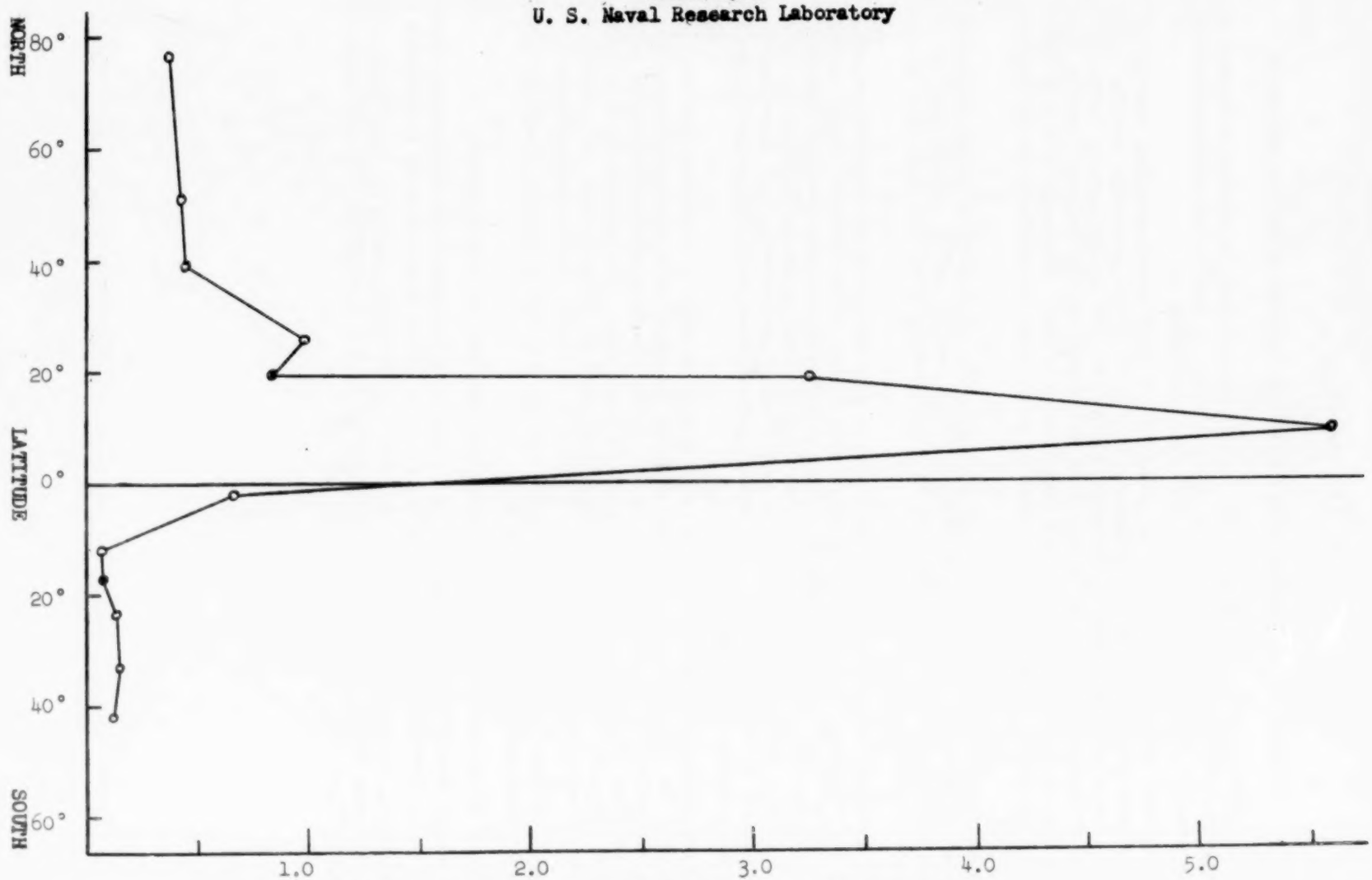
TABLE VIII.—U. S. NAVAL RESEARCH LABORATORY DAILY RECORD OF FISSION PRODUCT β—ACTIVITY COLLECTED BY AIR FILTRATION—Con.

March 1960

Disintegrations/minute per cubic meter of air							
Day	Mira-flores	San Juan	Mauna Loa	Miami	Wash-ington	Moosonee	Thule
1	18.48	3.1	1.34	1.47	0.41	0.52	0.35
2	18.48	3.1	1.34	1.47	0.41	0.44	0.35
3	9.40	3.1	1.49	1.93	0.38	0.35	0.51
4	9.40	3.1	1.49	1.93	0.38	0.32	0.51
5	12.60	14.42	1.36	0.71	0.50	0.51	0.37
6	12.60	14.42	1.36	0.71	0.50	0.41	0.37
7	12.60	11.91	1.36	0.71	0.50	0.74	0.37
8	15.34	11.91	0.81	0.71	0.65	0.48	0.37
9	15.34	11.91	0.81	0.71	0.65	0.25	0.32
10	10.53	11.91	0.98	1.11	0.52	0.30	0.33
11	10.53	3.75	0.98	1.11	0.52	0.35	0.33
12	4.27	3.75	1.52	0.92	0.35	0.30	0.27
13	4.27	3.75	1.52	0.92	0.35	0.28	0.27
14	4.27	3.75	1.52	0.92	0.35	0.39	0.27
15	2.78	1.64	0.98	1.28	0.49	0.30	0.39
16	2.78	1.64	0.98	1.28	0.49	0.30	0.39
17	2.15	0.67	0.45	1.28	0.13	0.46	0.37
18	2.15	0.67	0.45	1.28	0.13	0.48	0.37
19	0.74	0.39	0.45	0.77	0.59	0.39	0.37
20	0.74	0.39	0.45	0.77	0.59	0.35	0.39
21	0.74	0.39	0.45	0.77	0.59	0.35	0.39
22	0.25	0.21	0.48	0.82	0.46	0.39	0.62
23	0.25	0.21	0.48	0.82	0.46	0.35	0.62
24	0.18	0.05	0.31	0.67	0.48	0.37	0.31
25	0.18	0.05	0.31	0.67	0.48	0.41	0.31
26	0.21	0.08	0.30	0.77	0.21	1.29	0.28
27	0.21	0.08	0.30	0.77	0.21	0.41	0.28
28	0.21	0.08	0.30	0.77	0.21	0.35	0.28
29	0.16	0.35	0.23	0.76	0.28	0.32	0.30
30	0.16	0.35	0.23	0.76	0.28	0.46	0.30
31	0.13	0.12	0.25	0.43	0.91	0.41	0.32
Mean value	5.55	3.23	0.82	0.97	0.43	0.42	0.36

FIGURE 68
Average Measurements of Surface Air at 14 Stations Along 80th Meridian

March 1960
U. S. Naval Research Laboratory



SECTION IV

WATER

PUBLIC HEALTH SERVICE NATIONAL WATER QUALITY NETWORK

The National Water Quality Network was established under the provisions of Section 4(c) of Public Law 660, which states that ". . . the Surgeon General shall . . . collect and disseminate basic data . . . (relating) to water pollution and the prevention and control thereof."

This Network, operated in cooperation with State and local health agencies, was started in October 1957. At present there are 61 sampling stations located on major waterways used for public water supply, propagation of fish and wildlife, recreational purposes, and for agricultural, industrial and other uses; some of these stations are interstate, coastal, and International Boundary waters, and waters on which activities of the Federal Government may have an impact. Ultimately a total of 250 to 300 stations will be operated. A few of the more recently established stations have not yet begun to report radioactivity.

Samples of water are examined for chemical, physical, and biological quality insofar as these relate to pollution. Samples for some determinations are taken weekly, others monthly, and for some continuous composite samples of 10 to 15 days are obtained. Radioactivity determinations are made on single samples, taken weekly.

Gross alpha and beta measurements are made on both suspended and dissolved solids in the raw surface water samples. The radioactivity levels of dissolved solids provide a rough measure of the levels which may be found in a treated water, where such water treatment removes substantially all of the suspended matter. Naturally occurring radioactive substances in the environment are the source of essentially all of the alpha activity. The contamination of the environment from man-made sources is the major contributor to the beta activity. The results are reported in micromicrocuries per liter, and are shown for each station on a given river.

While beta determinations for the first two years of the Network operation have been done on each sample weekly, the alpha determinations are reported generally on a composite sample of more than one week. Beginning with samples taken in January 1960, beta determinations are to be performed on composite samples obtained by combining two weekly samples. The alpha data will be reported on three-month composite samples, with one-third of the stations being covered each month. All the data reported below represent the average of all information available for the month indicated.

Strontium-90 data are reported as being the results of determinations on composite sample for a three-month period ending in the month shown.

Additional information and data may be obtained from the following sources:

1. "National Water Quality Network Annual Compilation of Data," PHS Publication. For sale by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Price $1.50.

2. "Report on National Water Quality Control Network," submitted by Dr. F. J. Weber, Chief, Division of Radiological Health, PHS, to Joint Committee on Atomic Energy Hearings on Fallout from Nuclear Weapons Tests, Vol. 1, May 1959, Pages 167-169.

FIGURE 69

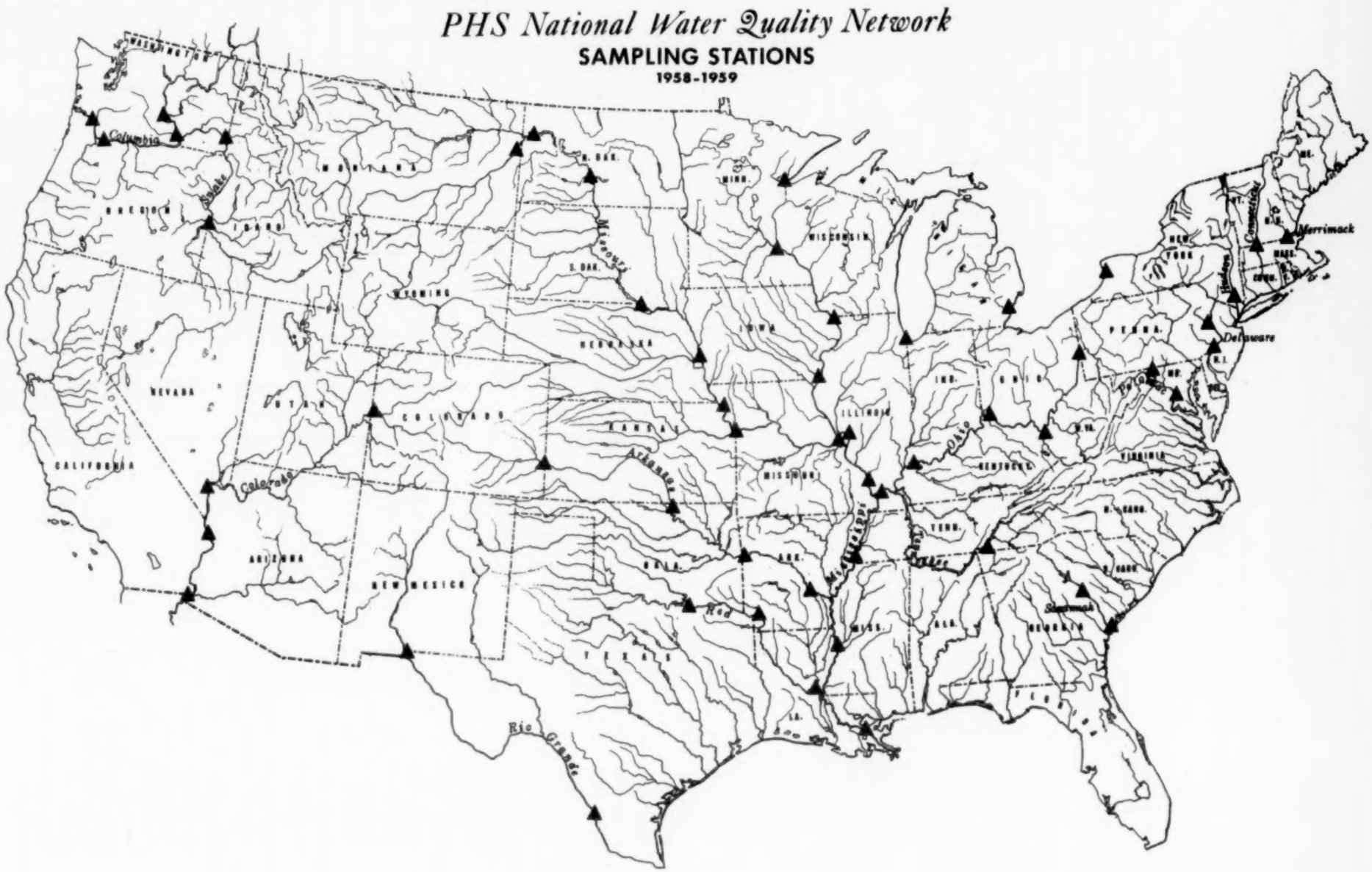

PHS National Water Quality Network
SAMPLING STATIONS
1958-1959
Columbia
Snake
Missouri
Arkansas
Colorado
Red
Rio Grande
Ohio
Tennessee
Mississippi
Delaware
Merrimack
Hudson
Connecticut
WASHINGTON
OREGON
IDAHO
NEVADA
CALIFORNIA
UTAH
COLORADO
ARIZONA
NEW MEXICO
WYOMING
MONTANA
N. DAK.
S. DAK.
NEBRASKA
KANSAS
OKLA.
TEXAS
MINN.
IOWA
MISSOURI
ARK.
LA.
WISCONSIN
ILLINOIS
MICH.
IND.
OHIO
KENTUCKY
TENN.
MISS.
ALA.
GA.
FLA.
W. VA.
VIRGINIA
N. CAROL.
S. CAROL.
PENNA.
N.Y.
MD.
DEL.
N.J.
CONN.
R.I.
MASS.
VT.
N.H.
ME.

TABLE IX.--U. S. PUBLIC HEALTH SERVICE NATIONAL WATER QUALITY NETWORK
RADIOACTIVITY-IN RAW SURFACE WATERS

(Micromicrocuries per liter)

Station	Quarter ending 12/31/59	Month of January 1960 (Average to nearest whole number)					
	Strontium-90	Beta activity			Alpha activity		
		Susp.	Dis.	Tot.	Susp.	Dis.	Tot.
ALSEA RIVER							
Alsea, Oreg.	0.2	0	0	0	0	0	0
ARKANSAS RIVER							
Coolidge, Kans.	0.4	3	5	8	-	-	-
Ponca City, Okla.	0.6	8	16	24	0	8	8
Fort Smith, Ark.	1.2	-	-	-	-	-	-
Pendleton Ferry, Ark.	0.6	54	6	60	5	1	6
CHATTAHOOCHIE RIVER							
Columbus, Ga.	0.2	2	2	4	0	0	0
COLORADO RIVER							
Loma, Colo.	0.3	15	40	55	2	4	6
Page, Ariz.	0.3	34	0	34	8	18	26
Hoover Dam, Ariz.-Nev.	0.7	0	4	4	1	10	11
Parker Dam, Ariz.-Calif.	0.7	0	3	3	<1	5	5
Yuma, Ariz.	0.6	0	0	0	<1	9	10
COLUMBIA RIVER							
Wenatchee, Wash.	0.8	1	6	7	0	2	2
Pasco, Wash.	0.9	61	472	533	0	1	1
Bonneville Dam, Oreg.	1.0	37	374	411	0	1	1
Clatskanie, Oreg.	0.5	148	38	186	0	0	0
CONNECTICUT RIVER							
Northfield, Mass.	0.3	-	-	-	-	-	-
DELAWARE RIVER							
Martin's Creek, Pa.	-	5	7	12	0	<1	<1
Philadelphia, Pa.	0.6	3	0	3	0	0	0
GREAT LAKES							
Gary, Ind.	0.4	0	1	1	0	0	0
Duluth, Minn.	0.3	3	9	12	0	0	0
Detroit, Mich.	0.7	<1	7	7	1	0	1
Buffalo, N. Y.	1.1	3	2	5	0	1	1
HUDSON RIVER							
Poughkeepsie, N. Y.	1.3	11	21	32	-	-	-
MERRIMACK RIVER							
Lowell, Mass.	0.5	2	4	6	-	-	-
MISSISSIPPI RIVER							
Red Wing, Minn.	0.7	0	4	4	0	3	3
Dubuque, Iowa	1.4	3	13	16	-	-	-
Burlington, Iowa	1.0	7	3	10	3	1	4
East St. Louis, Ill.	0.5	10	3	13	5	1	6
Cape Girardeau, Mo.	0.4	20	6	26	5	2	7
West Memphis, Ark.	1.3	8	6	14	3	0	3
Delta, La.	1.0	-	-	-	-	-	-
New Orleans, La.	0.9	10	4	14	6	4	10

TABLE IX.—U. S. PUBLIC HEALTH SERVICE NATIONAL WATER QUALITY NETWORK RADIOACTIVITY-IN RAW SURFACE WATERS—Con.

(Micromicrocuries per liter)

Station	Quarter ending 12/31/59	Month of January 1960 (Average to nearest whole number)					
	Strontium-90	Beta activity			Alpha activity		
		Susp.	Dis.	Tot.	Susp.	Dis.	Tot.
MISSOURI RIVER							
Williston, N. D.	0.5	0	4	4	0	5	5
Bismarck, N. D.	0.9	1	11	12	0	5	5
Yankton, S. D.	0.5	<1	2	3	1	6	7
Omaha, Nebr.	1.0	0	8	8	0	4	4
St. Joseph, Mo.	0.4	5	10	15	6	7	13
Kansas City, Kans.	0.7	24	13	37	6	4	10
St. Louis, Mo.	0.6	28	7	35	21	0	21
OHIO RIVER							
East Liverpool, Ohio	0.6	0	0	0	0	0	0
Huntington, W. Va.	0.2	7	1	8	1	2	3
Cincinnati, Ohio	0.8	1	<1	1	5	1	6
Evansville, Ind.	-	5	3	8	2	1	3
Cairo, Ill.	1.2	7	1	8	1	2	3
POTOMAC RIVER							
Williamsport, Md.	0.5	1	1	2	0	1	1
Great Falls, Md.	0.4	<1	0	<1	0	1	1
RED RIVER							
Denison, Tex.	1.9	0	4	4	0	0	0
Index, Ark.	0.9	3	3	6	1	3	4
Alexandria, La.	1.6	28	8	36	8	0	8
RIO GRANDE RIVER							
Laredo, Tex.	0.7	0	5	5	1	4	5
Brownville, Tex.	0.3	0	4	4	3	1	4
ST. MARY'S RIVER							
Sault Ste. Marie, Mich.	0.3	<1	0	<1	0	0	0
SAVANNAH RIVER							
North Augusta, S. C.	0.7	5	3	8	-	-	-
Port Wentworth, Ga.	0.7	2	8	10	0	0	0
SNAKE RIVER							
Wawawai, Wash.	0.4	0	10	10	0	3	3
TENNESSEE RIVER							
Chattanooga, Tenn.	1.1	15	32	47	-	-	-
YELLOWSTONE RIVER							
Sidney, Mont.	0.7	0	6	6	0	3	3

TABLE X.--HEALTH AND SAFETY LABORATORY--ATOMIC ENERGY COMMISSION

Strontium-90 in New York City Tap Water

(Micromicrocuries per liter of water)

Month 1959	Strontium-90	Sr-89/Sr-90 at midpoint of sampling month
December	0.63	0.7

TABLE XI.--STRONTIUM-90 DETERMINATIONS ON CISTERN WATER COMPOSITES

Monthly samples of several roof-collected U. S. Coast Guard rain water cistern supplies are routinely analyzed for beta activity by the Robert A. Taft Sanitary Engineering Center, Public Health Service, Cincinnati, Ohio. Some samples are composited each three months and further analyzed for strontium-90 activity. Additional data concerning this investigation appears in "Statement on New Data on Uptake In Milk, Food and Human Bone," by C. P. Straub, submitted to Joint Committee Hearings on Fallout from Nuclear Weapons, May 1959, Vol. II, Page 990.

Measurements for gross beta activity of monthly cistern water samples and other references appear in Radiological Health Data, June 1960 Monthly Report, Volume I, No. 3.

Strontium-90 Analyses on Cistern Water Composites

Location	Period collected	Strontium-90 $\mu\mu$c/l*
	(1959)	
Metomkin, Accoma, Va.	Oct., Dec.	3.5
Port O'Connor, Tex.	Oct., Nov., Dec.	1.7
Grand Isle, La.	Oct., Nov., Dec.	2.0
Cape Hatteras, Buxton, N. C.	Oct., Dec.	1.6
Patos Island, Bellingham, Wash.	Oct., Nov., Dec.	1.0
Cape Flattery, Neah Bay, Wash.	Oct., Nov.	3.3
Cobb Island, Oyster, Va.	Oct., Nov.	2.9
Moose Peak, West Jones Port, Maine	Oct., Dec.	1.7
Swansboro, N. C.	Oct., Dec.	2.9
Cuckolds, Newagen, Maine	Oct., Dec.	1.6
Hamilton County, Ohio	November	3.6
Hamilton County, Ohio	Oct., Nov., Dec.	2.7

*Average error $\pm$0.1.

SECTION V

OTHER DATA

STRONTIUM-90 ACTIVITY IN HUMAN BONE

From St. Louis, Missouri Area--Public Health Service

The first set of data from a continuing program of collection and radiochemical analyses of human bones from St. Louis and its environs is tabulated in Tables XII and XIII below. For comparative purposes, Table XIV shows the strontium-90 activity in children's bones for North America as reported by the Geochemical Laboratory, Lamont Geological Observatory, Columbia University.

Although the strontium-90 values for the "Fetus" age group for the St. Louis data are somewhat higher than for "North America," and the reverse is true for the "0-1 year" age group, the number of speciments to date is too small to permit firm conclusions.

TABLE XII.--STRONTIUM-90 ANALYSES--HUMAN BONE SAMPLES

Age	Sex	Type of bone	Quarter and year of death		Bones (Grams)			Strontium-90 ($\mu\mu$c/Gram)		
					Dry	Ash	CaO	Bone	Ash	Ca
Fetal and stillborn:										
Stillborn	F	Vertebra	3	1959	17.1	4.9	(*)	(*)	**0.49	**1.35
6 month fetal		Vertebra	3	1959	8.0	2.2	1.25	0.17	0.59	1.48
Stillborn	M	Femur, lumbar/ vertebra	3	1959	27.6	6.7	3.37	0.07	0.30	0.77
Stillborn	M	Lumbar vertebra	4	1959	17.4	6.1	(*)	(*)	**0.47	**1.30
Stillborn	M	Lumbar vertebra/ribs	3	1959	27.1	8.0	4.25	0.15	0.50	1.32
Stillborn	M	Vertebra	4	1959	29.1	9.0	4.70	0.14	0.44	1.16
Stillborn	M	Vertebra	4	1959	12.8	3.0	1.59	0.07	0.30	0.81
Stillborn	M	Vertebra	4	1959	7.4	2.5	1.33	0.16	0.49	1.37
Newborn (Up to age 1 year):										
8 weeks	(*)	Lumbar vertebra	4	1959	21.1	5.0	2.66	0.18	0.76	2.0
6 weeks	F	Lumbar vertebra	4	1959	7.7	2.4	1.28	0.17	0.54	1.42
17 hours	M	Vertebra	4	1959	21.3	3.7	1.95	0.05	0.26	0.70
1 month	F	Rib, sternum,/ vertebra	4	1959	6.2	1.7	0.95	0.29	1.05	2.81
4 months	M	Vertebra	1	1960	16.0	3.2	1.70	0.23	1.15	3.04
Children (Age 1-10 years):										
9 years	F	Vertebra column	3	1959	39.3	9.6	5.03	0.02	0.08	0.21
17 months	M	Skull, vertebra	3	1959	15.1	7.5	3.97	0.06	0.13	0.36
9 years	M	Vertebra	4	1959	6.2	1.6	0.85	0.31	1.23	3.3
4 years	M	Vertebra	4	1959	42.8	8.6	(*)	(*)	**0.69	**1.90
9 years	M	Vertebra	4	1959	50.7	7.6	(*)	(*)	**0.40	**1.08
14 months	M	(*)	4	1959	29.5	5.9	3.14	0.19	0.98	2.58
5 years	M	Vertebra	1	1960	28.8	5.7	3.02	0.11	0.57	1.53
1-1/2 years	M	Vertebra	1	1960	18.6	4.1	2.18	0.06	0.28	0.74
10 years	F	Vertebra	1	1960	76.0	10.6	5.63	0.04	0.26	0.68
6 years	M	Vertebra	1	1960	43.9	9.2	4.89	0.14	0.65	1.74
3 years	M	Vertebra	(*)	(*)	25.9	4.2	2.24	0.17	1.04	2.78
Children (Age 11-20 years):										
11 years	F	Rib, vertebra	3	1959	23.7	6.7	3.52	0.08	0.30	0.79
15 years	F	Vertebra column	3	1959	26.7	7.6	3.99	0.01	0.04	0.09
12 years	M	Lumbar vertebra	3	1959	116.5	32.7	17.40	0.09	0.31	0.81
15 years	M	Lumbar vertebra	4	1959	154.8	16.8	8.9	0.05	0.45	1.19
13 years	F	Vertebra	1	1960	59.1	10.1	5.35	0.11	0.67	1.79

*Undetermined. **Radiochemical analyses performed by the Health and Safety Laboratory, A.E.C.

* Undetermined. ** Radiochemical analyses performed by the Health and Safety Laboratory, AEC.

TABLE XII.--STRONTIUM-90 ANALYSES--HUMAN BONE SAMPLES--Con.

Age	Sex	Type of Bone	Quarter and year of death	Bones (Grams)			Strontium-90 ($\mu\mu$c/Gram)		
				Dry	Ash	CaO	Bone	Ash	Ca
Adults (Age 21 or older):									
33 years	F	Rib, vertebra	3 1959	45.1	16.4	9.07	0.05	0.14	0.36
54 years	M	Rib, vertebra	3 1959	36.7	11.0	6.01	0.05	0.18	0.47
71 years	M	Vertebra	3 1959	131.3	32.2	18.00	0.05	0.20	0.48
57 years	F	Vertebra	3 1959	47.1	10.4	5.82	0.05	0.23	0.63
68 years	F	Vertebra	3 1959	102.8	12.7	7.12	0.02	0.19	0.47
37 years	M	Rib, vertebra	3 1959	46.6	16.8	9.35	0.00	0.002	0.005
80 years	F	Lumbar vertebra	3 1959	33.1	8.3	4.47	0.09	0.25	0.63
72 years	M	Lumbar vertebra	3 1959	53.4	8.4	4.57	0.03	0.18	0.46
47 years	M	Lumbar vertebra	3 1959	98.8	20.6	10.80	0.05	0.26	0.75
44 years	M	Lumbar vertebra	3 1959	50.4	9.2	4.82	0.03	0.19	0.50
49 years	F	Vertebra	3 1959	39.5	10.8	5.67	0.01	0.05	0.13
48 years	M	Rib, vertebra	2 1959	183.7	41.5	21.70	0.01	0.06	0.17
69 years	M	Lumbar vertebra	3 1959	58.3	14.0	7.5	0.04	0.15	0.40
87 years	M	Lumbar vertebra	3 1959	92.0	23.2	12.35	0.07	0.28	0.74
61 years	M	Lumbar vertebra	3 1959	74.0	13.8	7.40	0.03	0.16	0.43
47 years	M	Lumbar vertebra	3 1959	52.5	12.6	6.7	0.09	0.37	0.99
75 years	M	Lumbar vertebra	3 1959	105.2	25.4	13.52	0.03	0.12	0.32
46 years	M	Lumbar vertebra	3 1959	49.4	14.1	7.5	0.03	0.11	0.30
48 years	M	Vertebra	3 1959	48.1	15.3	8.10	0.02	0.08	0.22
81 years	F	Lumbar vertebra	3 1959	76.3	11.7	6.20	0.02	0.16	0.43
72 years	F	Lumbar vertebra	3 1959	58.5	9.0	4.80	0.05	0.34	1.40
69 years	F	Lumbar vertebra	3 1959	59.5	14.9	7.93	0.09	0.40	0.86
43 years	F	Lumbar vertebra	3 1959	60.2	10.2	5.44	0.03	0.21	0.57
79 years	M	Lumbar vertebra	3 1959	82.5	15.7	8.35	0.12	0.66	1.78
80 years	F	Lumbar vertebra	3 1959	43.6	6.4	3.40	0.02	0.21	0.55
81 years	F	Lumbar vertebra	3 1959	30.6	4.5	2.40	0.03	0.20	0.54
43 years	F	Lumbar vertebra	3 1959	55.0	10.4	5.54	0.05	0.27	0.71
53 years	F	Lumbar vertebra	3 1959	53.9	10.7	5.70	0.10	0.48	1.28

TABLE XIII.—SUMMARY ST. LOUIS HUMAN BONE DATA

(Strontium-90)

	Bone $\mu\mu$c/gm			Ash $\mu\mu$c/gm			Calcium $\mu\mu$c/gm		
	High	Avg.	Low	High	Avg.	Low	High	Avg.	Low
I. Fetal and stillborn: Total 8 specimens	0.17	0.13	0.07	0.59	0.45	0.30	1.48	1.20	0.77
II. Infant 0-1 year: Total 5 specimens	0.29	0.18	0.05	1.15	0.75	0.26	3.04	1.99	0.70
III. Children 1-10 years: Total 11 specimens	0.31	0.12	0.02	1.23	0.57	0.08	3.30	1.54	0.21
IV. Adolescents 11-20 years: Total 5 specimens	0.11	0.07	0.01	0.67	0.35	0.04	1.79	0.93	0.09
V. Adults over 20 years: Total 28 specimens	0.12	0.04	0.00	0.66	0.22	0.002	1.78	0.59	0.005

TABLE XIV.—COMPARISON OF STRONTIUM-90 ACTIVITY IN HUMAN BONES OF ST. LOUIS AREA AND NORTH AMERICA*

Age	St. Louis Area Sr-90 $\mu\mu$c/gm Ca	North America Sr-90 $\mu\mu$c/gm Ca
Fetus	1.20 (8)	0.92 (59)
0-1	1.99 (5)	2.50 (15)
1-10	1.54 (11)	1.66 (30)
11-20	0.93 (5)	0.84 (23)

Note.—Figures in parentheses are number of specimens in each age group from which averages are derived.

* From the Third Quarterly Statement on Fallout by the Atomic Energy Commission, January 1960, as reported by the Geochemical Laboratory, Lamont Geological Observatory, Columbia University.

PUBLIC HEALTH SERVICE--RADIOCHEMICAL ANALYSES OF FOOD

The following data are abstracted from "Radionuclides in Foods" presented at the Annual Meeting of the Ohio Dietetic Association, Cincinnati, Ohio, May 5-6, 1960, a paper by Conrad P. Straub, G. K. murthy and J. E. Campbell of the Robert A. Taft Sanitary Engineering Center, Public Health Service, Cincinnati, Ohio. All food items were from the Cincinnati, Ohio markets. The radiochemical analyses were performed by the PHS Robert A. Taft Sanitary Engineering Center.

TABLE XV.--CALCIUM AND STRONTIUM-90 CONTENT OF FOODS

(Cincinnati, Ohio)

Foods	Origin	Date of sampling	Ca (gm/kg)	Sr^{90} ($\mu\mu c$/kg)
Beets	Texas	3-12-59	0.120	10.3
Broccoli	California	3-12-59	1.127	5.3
Cabbage	Texas	3-12-59	0.355	7.1
Carrots	California	3-12-59	0.363	4.1
Cauliflower	California	3-12-59	0.196	2.3
Celery	California	3-12-59	0.620	2.8
Coconut	South Sea	3-12-59	0.128	1.7
Cucumber	Michigan	9-23-59	0.111	13.3
Kale	?	3-12-59	0.785	74.7
Lettuce	California	3-12-59	0.183	1.4
Mustard greens	?	9-23-59	1.422	40.0
Potato	Idaho	3-12-59	0.100	1.4
Radish	Florida	3-12-59	0.256	3.4
Spinach	Texas	3-12-59	1.406	36.5
String beans	Florida	3-12-59	0.515	43.2
Sweet potato	Tennessee	3-12-59	0.241	13.5
Turnip	Florida	3-12-59	0.422	10.6
Turnip greens	Florida	9-23-59	2.703	32.0
White flour	Minnesota	3-12-59	0.513	25.2
Whole wheat flour	Minnesota	9-23-59	0.266	56.2
Whole wheat flour	Minnesota	1- -60	0.328	47.5

TABLE XVI.—CALCIUM, POTASSIUM, GROSS β-AND SPECIFIC RADIONUCLIDE CONTENT OF FOODS

(Cincinnati, Ohio)

Sample	Date of sampling	Ca (gm/kg)	K (gm/kg)	Gross β-activity	Sr^{89}	Sr^{90}	Ba^{140}[a]	Cs^{137}[b]	Ra^{226}	Zn^{65}	Zr^{95} Nb^{95+}	Ru^{106} Rh^{106+}
				$\mu\mu$c/kg								
Eggs	9-23-58	0.695	1.369	1,360	-	3.0	0	2.0	0.52	6	0	0
Fruits	8-28-58	0.178	2.484	2,190	-	3.7	2.4	63.4	-	3	6	22
Fruit juices	9-23-58	0.128	1.791	1,780	-	2.1	0	31.2	0.08	-	-	-
Pastries	7-23-58	0.428	1.307	1,180	0	10.6	0	75.0	0.28	-	5	15
Cereals	6-12-58	0.480	1.365	2,540	-	12.4	0	113.5	0.12	-	50	134
Dairy products	7-16-58	4.836	-	540	61	39.0	0	21.2	0	-	-	-
Sea foods	7-16-58	0.335	-	2,310	0	0.2	0	24.8	-	-	-	-
Meats	8-27-58	0.172	3.483	2,520	0	1.0	0	160.0	0.10	17	6	26
Leafy vegetables	8-4-58	0.508	3.404	2,840	21	3.9	12.2	49.0	0	12	69	220
Root vegetables	8-4-58	0.273	3.632	3,230	46	12.5	2.8	53.3	0	10	13	60
Legumes and corn	8-4-58	0.234	3.132	3,240	32	7.5	0	57.0	0	4	13	83
Instant coffee	6-20-58	1.900	44.280	40,100	31	19.0	0	1,860.0	-	-	58	0
Instant tea	7-23-58	0.150	45.320	45,300	150	60.0	-	894.0	-	-	420	1,150
Mixed nuts	8-26-58	0.727	6.975	6,300	-	8.2	0	348.0	2.23	-	-	-
	9-23-58	0.643	6.650	6,110	6	8.1	0	208.0	0.19	-	-	-
Rice	8-26-58	0.196	0.811	740	-	1.2	0	95.0	0	-	5	19
Milk	1958	1.145			55	8.5	24	75.0	0	4	0	0

([a]) Uncorrected for decay to time of collection.
([b]) In ash only.
- Not determined.
0 Means below detectability.

TABLE XVII.--CALCIUM AND STRONTIUM-90 CONTENT OF MEALS

(Cincinnati, Ohio)

Sample No.	Date of sampling	Ca (gm/meal)	Sr^{90} ($\mu\mu$c/meal)
	Lunch		
1	October 1959	0.268	6.1
2	November 1959	0.158	6.5
3	November 1959	0.352	6.7
4	November 1959	0.261	7.7
5	November 1959	0.173	2.2
6	December 1959	0.242	2.6
7	December 1959	0.510	6.8
8	January 1960	0.259	4.3
9	January 1960	0.116	2.1

Meal No. 1--Tossed salad with dressing (34.5 g), Frankfurters (105.7 g), Creamed Potato (193.2 g), Peas (76.4 g), White Bread (43.1 g), Butter (5.0 g) and Milk (250.0 g). Total (707.9 g).

Meal No. 2--Eggs, celery and lettuce salad (82.7 g), Roast beef (121.4 g), Rice (139.0 g), Creamed green beans (114.4 g), rye bread (41.3 g), Cherry pie (150.7 g), and Coffee with cream and sugar (162.7 g). Total (812.2 g).

Meal No. 3--Tossed salad with dressing (73.6 g), Roast pork (144.3 g), Peas (80.9 g), Beets (68.3 g), 1 rye and 1 white bread (41.8 g), Creamed potatoes (90.5 g) and Milk (250.0 g). Total (749.4 g).

Meal No. 4--Strawberry flavored jello (159.2 g), Fried chicken (104.5 g), Candied carrots (108.0 g), mustard greens (102.0 g), white bread (38.5 g), butter (5.0 g), pineapple (144.5 g) and hot tea (161.5 g). Total (823.2 g).

Meal No. 5--Fried fish with tartar sauce (89.8 g), mixed vegetables--corn, carrots, lima beans and string beans (118.1 g), stewed tomatoes (94.1 g), rye bread (43.0 g), butter (5.0 g), pineapple pudding with whipped cream and chocolate chip (110.1 g) and vegetable juice (186.5 g). Total (647.1 g).

Meal No. 6--Chopped liver, lettuce sandwich (95.3 g), split pea soup (219.2 g), peach pie (171.6 g) and Milk (177.8 g). Total (663.9 g).

Meal No. 7--Spaghetti with cheese (208.0 g), tossed salad with dressing (80.0 g), carrots (91.3 g), bread (40.2 g), butter (5.0 g) and milk (245.6 g). Total (669.8 g).

Meal No. 8--Roast beef sandwich: 2 slices of bread (34.8 g), roast beef (47.3 g), gravy (63.0 g), milk (244 g), french fried potatoes (142.3 g). Total (531 g). Ash 5.18 g

Meal No. 9--Fish sandwich: 2 slices of bread (33.6 g), fish (88.0 g), tossed salad with french dressing (106 g), fruit jello (223.2 g), coffee with cream and sugar (142.8 g). Total (593.6 g). Ash 4.76 g

TABLE XVIII.--CALCIUM AND STRONTIUM-90 CONTENT OF MEALS

(Cincinnati, Ohio)

Sample No.	Date of sampling	Ca (gm/meal)	Sr^{90} ($\mu\mu$c/meal)
	Breakfast		
1	January 1960	0.136	2.0
2	January 1960	0.597	3.9
3	January 1960	0.310	5.1
4	January 1960	0.310	3.7
5	January 1960	0.397	5.4
6	January 1960	0.122	1.2
7	January 1960	0.200	3.4
8	January 1960	0.279	4.5

Meal No. 1--Fried eggs (92.3 g), Buttered Toast (40.1 g), Sausage (89.1), Apple Jelly (12.6 g), and Coffee, black with sugar (143.5 g). Total (377.6 g).

Meal No. 2--Bacon (24.2 g), Pancakes (200.7 g), Corn Syrup (58.0 g), Coffee, black with sugar (136.5 g). Total (419.4 g).

Meal No. 3--Doughnuts (103.7 g) and Milk (245.7 g). Total (349.4 g).

Meal No. 4--Grapefruit Juice (185.2 g), 2-Fried Eggs (102.0 g), Buttered Toast (64.2 g), Jelly (17.5 g), and Milk (244.5 g). Total (613.4 g).

Meal No. 5--Orange Juice (178.2 g), Cornflakes with Milk (181.5 g), Milk (245.0 g), and Coffee (165.4 g). Total (770.1 g).

Meal No. 6--Stewed Prunes (171.5 g), 1-Fried Egg (39.8 g), Ham (63.3 g), Buttered Toast (67.6 g), Jelly (11.3 g) and Coffee (160.2 g). Total (513.7 g).

Meal No. 7--Tomato Juice (175.2 g), Oatmeal with Milk and Sugar (387.3 g), Buttered Toast (68.2 g), Jelly (15.1 g), Coffee (169.3 g). Total 815.1 g.

Meal No. 8--Cornflakes (30.1 g), Milk (150.4 g), 1 Egg (39.0 g), 3 Strips of Bacon (15.9 g), Buttered Toast (66.5 g) and Coffee (157.1 g). Total (459.0 g).

TABLE XIX.—STRONTIUM-90 ANALYSIS OF CEREALS

(Purchased at Cincinnati, Ohio)

Type cereal	Date of purchase	Strontium-90 $\mu\mu$c/kg
Brand A 100 percent bran	April 5, 1960	94.5 ± 3.2
Brand B All-bran	April 5, 1960	70.5 ± 2.8
Brand B 40 percent bran flakes	April 5, 1960	27.8 ± 1.4
Brand C 40 percent bran flakes	April 5, 1960	25.2 ± 1.3
Brand D shredded wheat	April 5, 1960	16.0 ± 1.1
Brand A shredded wheat	April 5, 1960	11.9 ± 0.6

RADIOACTIVITY IN FISH

Minnesota Department of Conservation

The Minnesota Department of Conservation has reported the results of their studies extending from early 1958 through July 1959 on the levels of radioactivity in fish in the State of Minnesota. The average values of "whole fish' for this period of time were reported as follows:

$\mu\mu$c strontium-90/Kg whole fish..... 131
$\mu\mu$c strontium-90/grams calcium whole fish..... 17.2

Of particular interest were the results of analyses of different parts of six fish. These data are contained in Table XX.

TABLE XX.--STRONTIUM-90 LEVELS IN MINNESOTA FISH

Date collected	Species and Lab. No.	Waste				Bones				Flesh				Skin			
		μμc Beta-activity/gm	μμc Sr^{90}/kg	μμc Sr^{90}/gmCa	gm Ca/kg	μμc Beta-activity/gm	μμc Sr^{90}/kg	μμc Sr^{90}/gmCa	gm Ca/kg	μμc Beta-activity/gm	μμc Sr^{90}/kg	μμc Sr^{90}/gmCa	gm Ca/kg	μμc Beta-activity/gm	μμc Sr^{90}/kg	μμc Sr^{90}/gmCa	gm Ca/kg
7/58	Walleye ...7139	0.32	50.1	3.1	6.0	19	700	6.9	101	4.5	10.9	14.9	0.73	0.36	7.9	12.9	0.61
7/58	Crappie ...7507	6.3	580	27.9	20.6	29	2,100	25.6	86.6	0.04				0.87			
1/59	Crappie ...9570		750	30.6	24		480	20.1	24						10.7	16.9	0.65
2/59	Northern..9883	3.8	170	12.3	14	2.3	420	15.5	27	2.3	7.2	15.2	0.48	2.3	27	24.8	1.1
4/59	Northern.....21	3.6	160	10.6	15	4.9	260	8.3	32	44	3.9	11.1	0.35	2.5	6.6	8.5	0.77
4/59	Northern.....45	4.1	160	9.9	17	7.1	400	8.2	49	4.0	26	15.6	1.6	2.5	16	13.5	1.2

FISSION PRODUCTS RADIOACTIVITY IN SOIL

Argonne National Laboratory
Atomic Energy Commission

For about the past three years, analyses of soil samples have been collected periodically near Argonne National Laboratory and analyzed for gamma emitting fission products, by Dr. Philip F. Gustafson, of ANL. These data have been reported in the Atomic Energy Commission 's Quarterly Statements on Fallout and were presented at the December 1959 meeting of the Radiological Society of North America in a paper "Assessment of the Radiation Dose Due to Fallout" by Dr. Gustafson. The following six figures (numbers 70 through 75) are based on these data. The data in Table XXI were received after the preparation of the graphs. For purposes of comparison, a radiological decay curve for each radionuclide is drawn on the graph with the starting point selected arbitrarily at the time of highest soil activity for the nuclide.

By integrating under a smoothed curve connecting the points on the graphs it is possible to calculate (using Dr. Gustafson's methods) the theoretical out-of-doors gamma exposures from these radio - nuclides in the soil.* These exposures are summarized as follows:

(a) From May 1957 to April 1959 ..... ~90 millirads
(About 85 millirads from shorter lived radionuclides and about 5 millirads from cesium-137)

(b) Peak year (1959) ..... ~50 millirads

As one point of reference in interpreting the calculations, the external gamma radiation exposure from natural background is roughly 100 millirads per year. Thus, the calculated out-of-doors dose from fallout (based on these soil data) is about 1/3 of natural background for the period May 1957 to April 1959 and about 1/2 for the peak year.

The calculated out-of-doors dose rate in April 1960 was roughly 1.6 millirads per month, or about 1/5 that of natural background. In the absences of further atmospheric nuclear weapons testing, it would be expected that the downward trend of dose rates would continue since the radiological decay of the radionuclides more than compensate for the small additional deposition from the atmosphere. Eventually, of course, the gamma does rate will level off to that of cesium-137 (half-life of 27 years).

The shielding effect of normal structures will reduce the in-door radiation exposures from those calculated out-of-doors. Using an ionization chamber Dr. Gustafson found a reduction factor of approximately five for in-door dose rates compared to those of out-of-doors. The structures used for this test were relatively large frame buildings or were of the cinder-block construction. It would be expected that a more usual frame home would have somewhat less shielding effects. The actual radiation exposure that persons might receive would depend, of course, not only on the type of structure but also on the length of time it was occupied.

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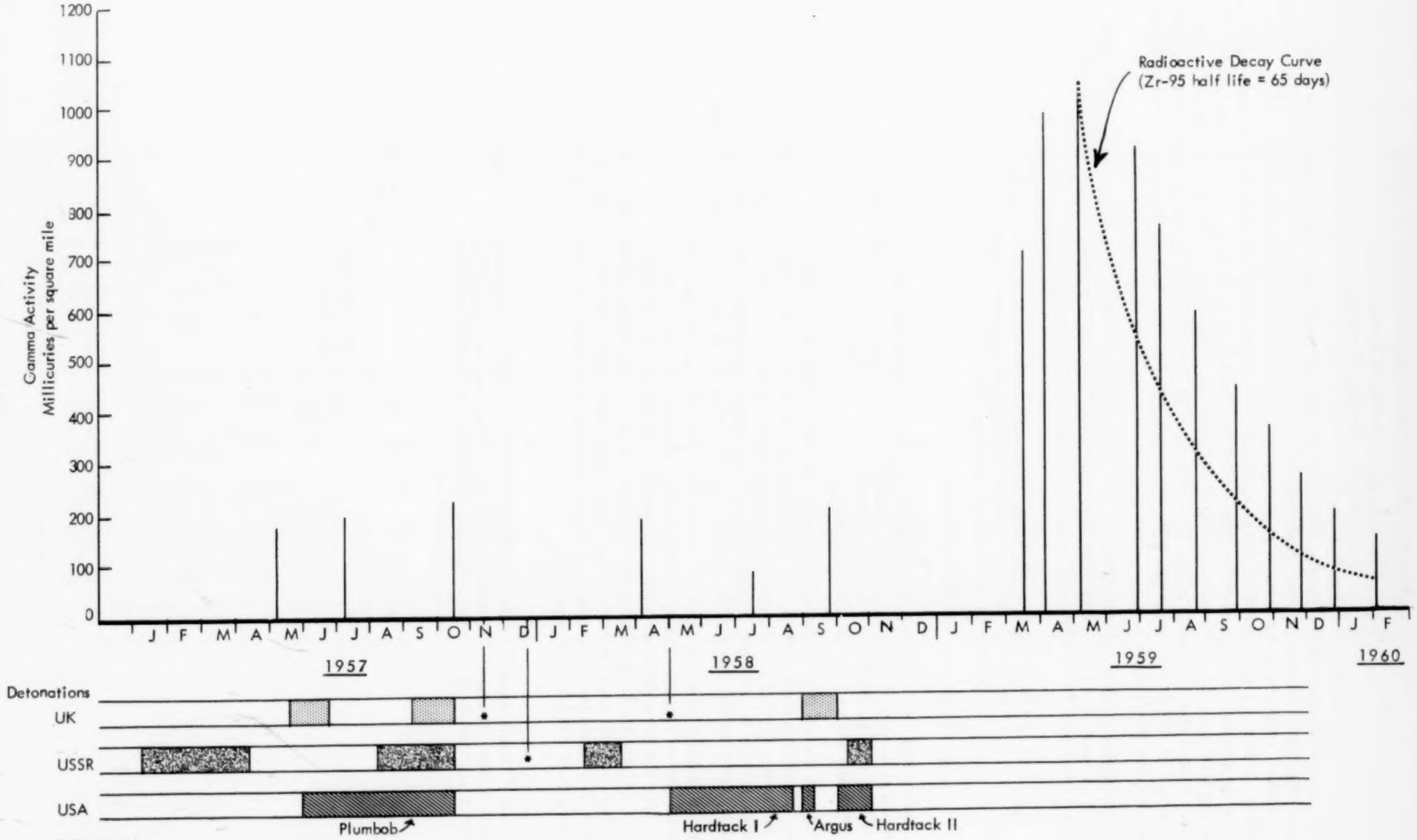
*Barium^{140}-lanthanum^{140} were not measured but it would be expected that these would contribute some additional gamma exposure. Although their half-lives are relatively short (12.8 days and 40 hours) they are present initially in relatively great abundance in fission products.

FIGURE 70

ZIRCONIUM-95 -NIOBIUM-95 RADIOACTIVITY IN SOIL AT ARGONNE NATIONAL LABORATORY**



* Single shot

** Activity of Zirconium-95 (assuming that Zirconium-95 and Niobium-95 are in equilibrium)

FIGURE 71

CESIUM-137 RADIOACTIVITY IN SOIL AT ARGONNE NATIONAL LABORATORY

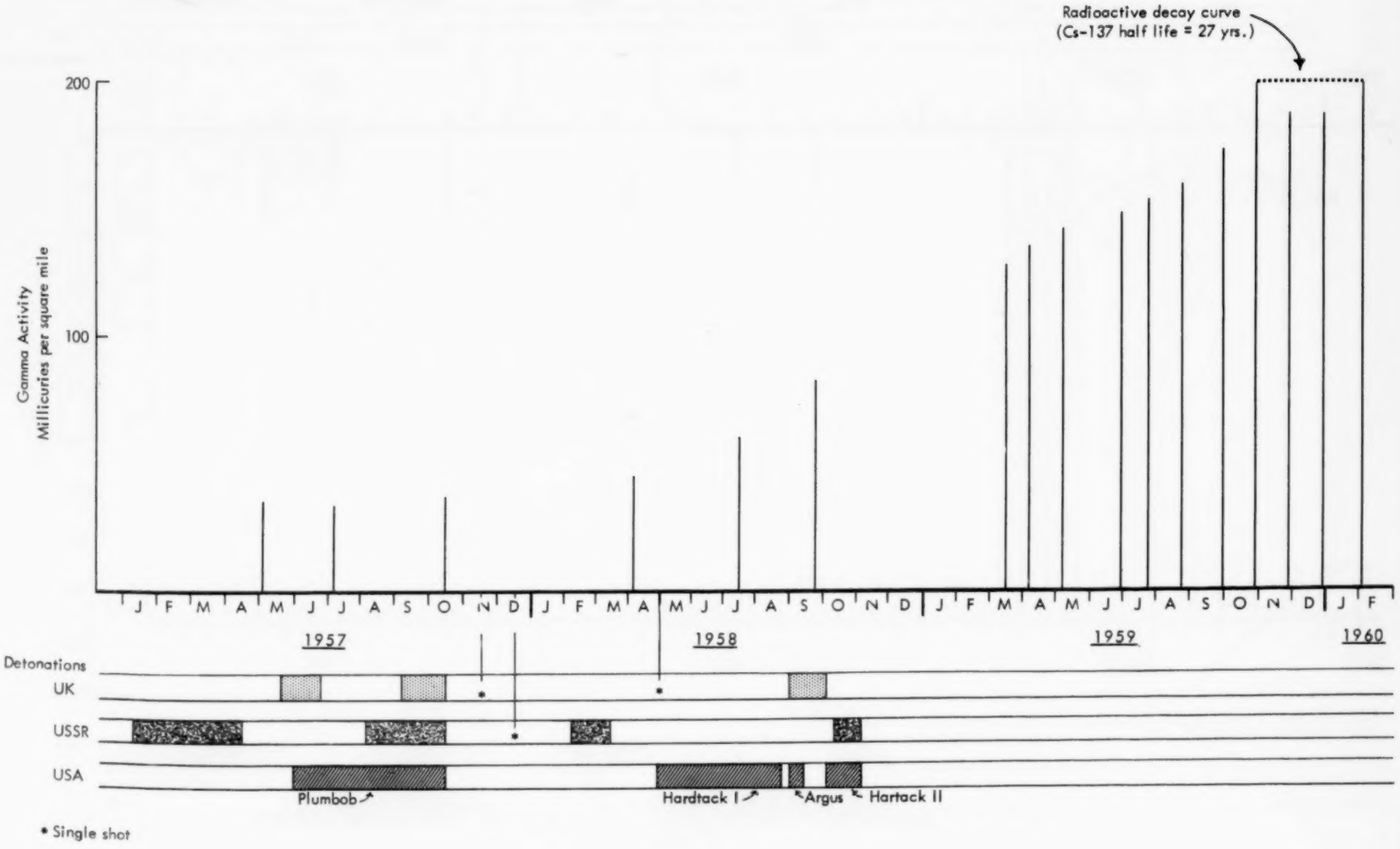


FIGURE 72

RUTHENIUM-106 RADIOACTIVITY IN SOIL AT ARGONNE NATIONAL LABORATORY

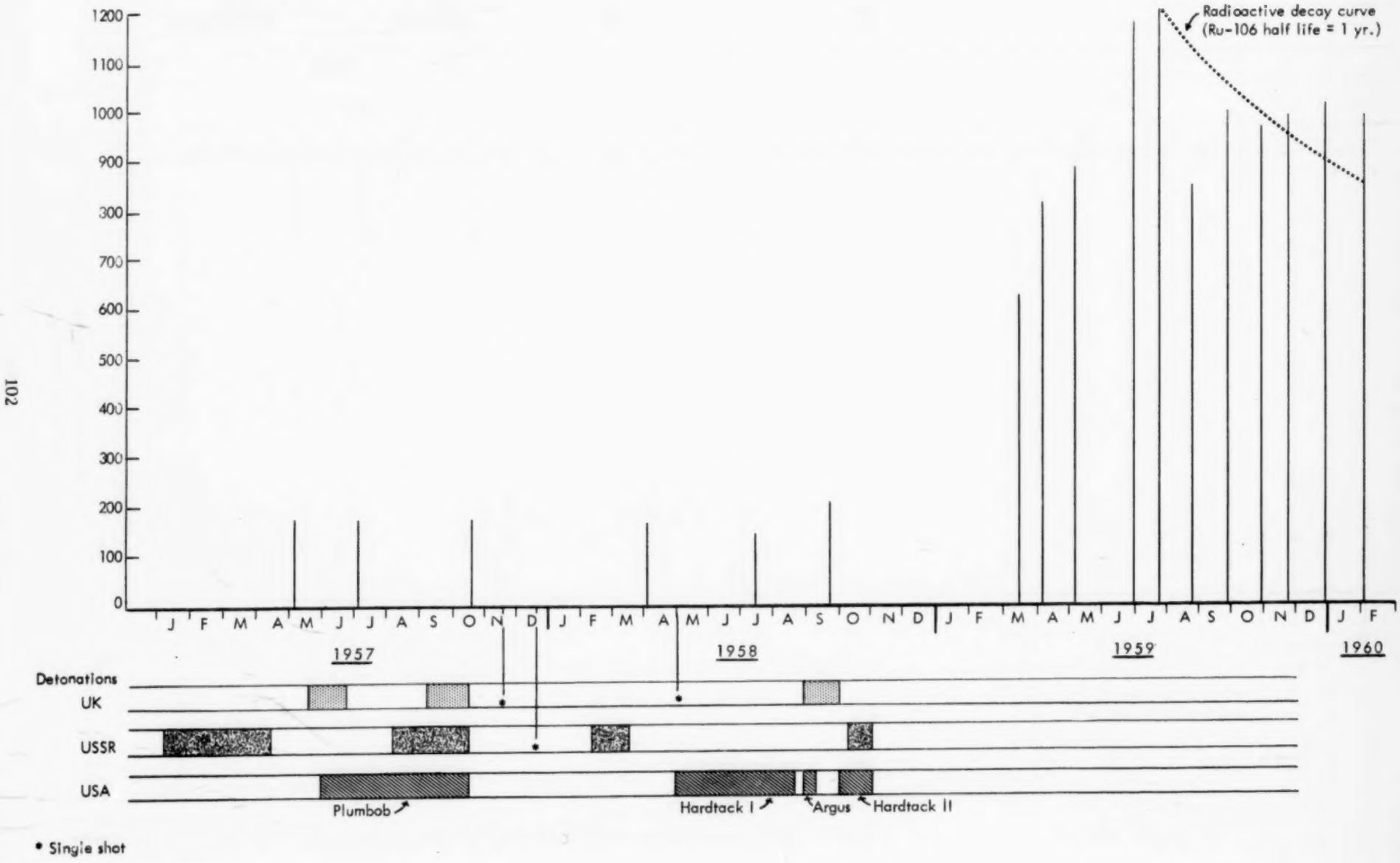
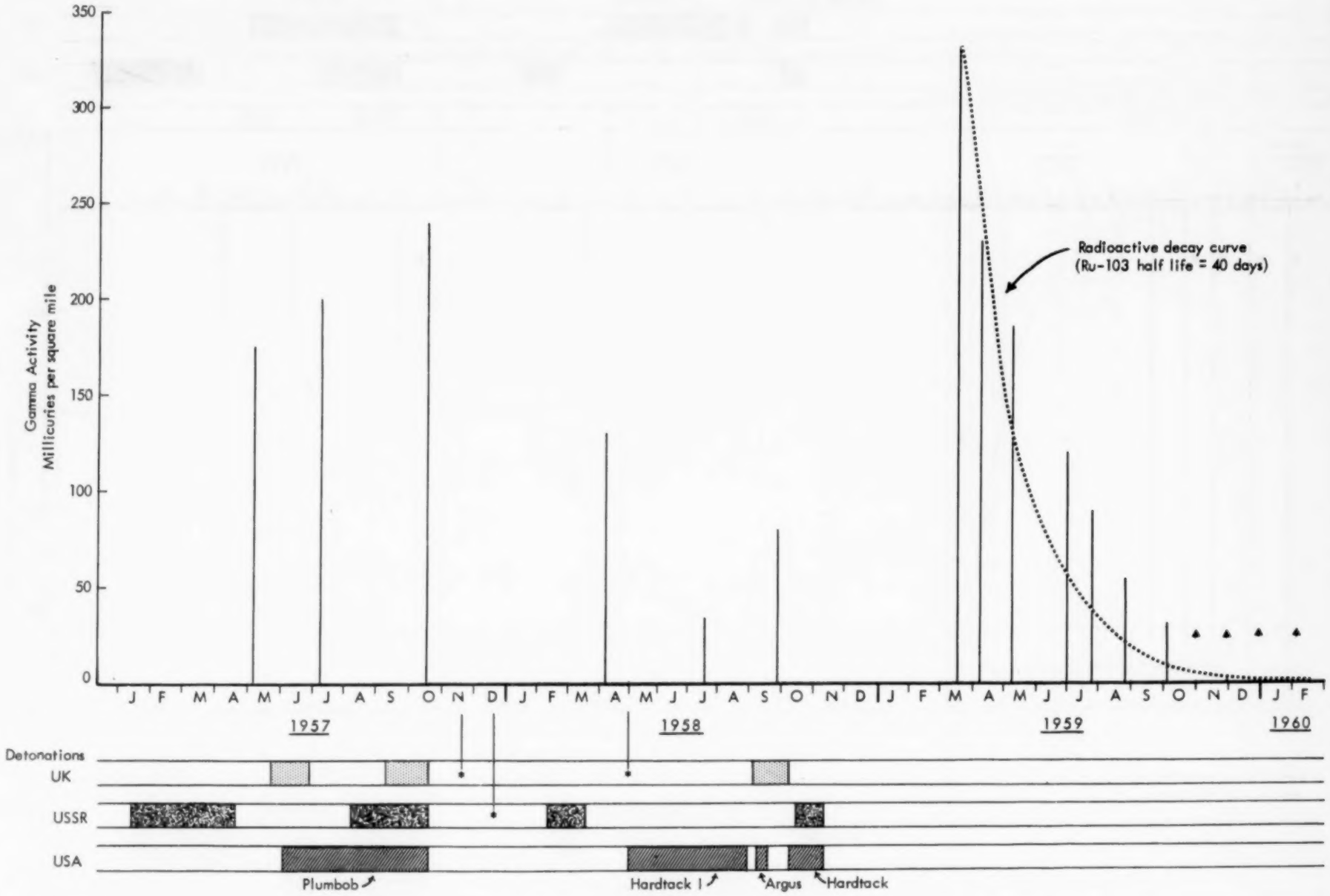


FIGURE 73

RUTHENIUM-103 RADIOACTIVITY IN SOIL AT ARGONNE NATIONAL LABORATORY

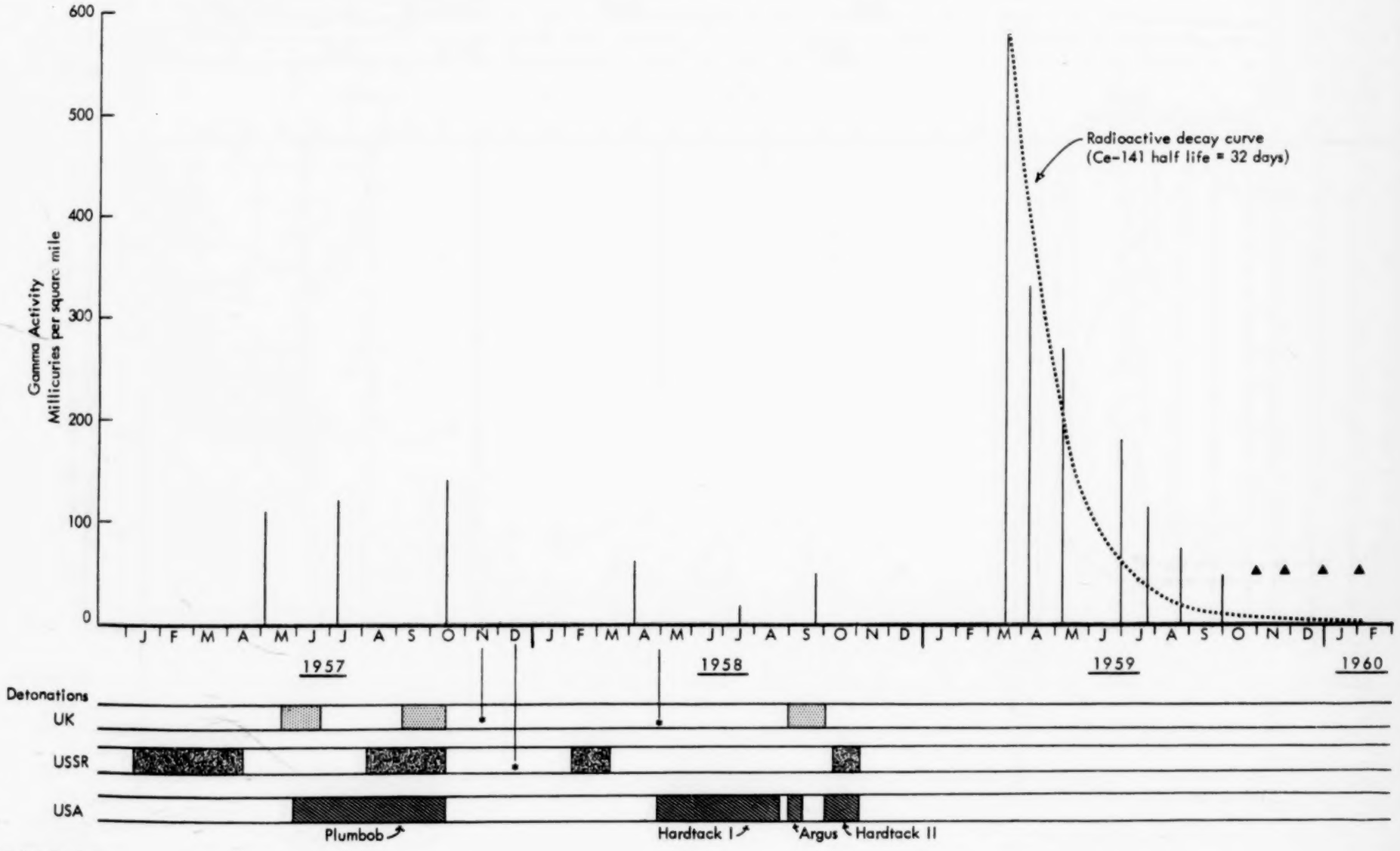


• Single shot

▲ Measurements for these months were below instrument detectability

FIGURE 74

CERIUM-141 RADIOACTIVITY IN SOIL AT ARGONNE NATIONAL LABORATORY



• Single shot

▲ Measurements for these months were below instrument detectability

FIGURE 75

CERIUM-144 RADIOACTIVITY IN SOIL AT ARGONNE NATIONAL LABORATORY

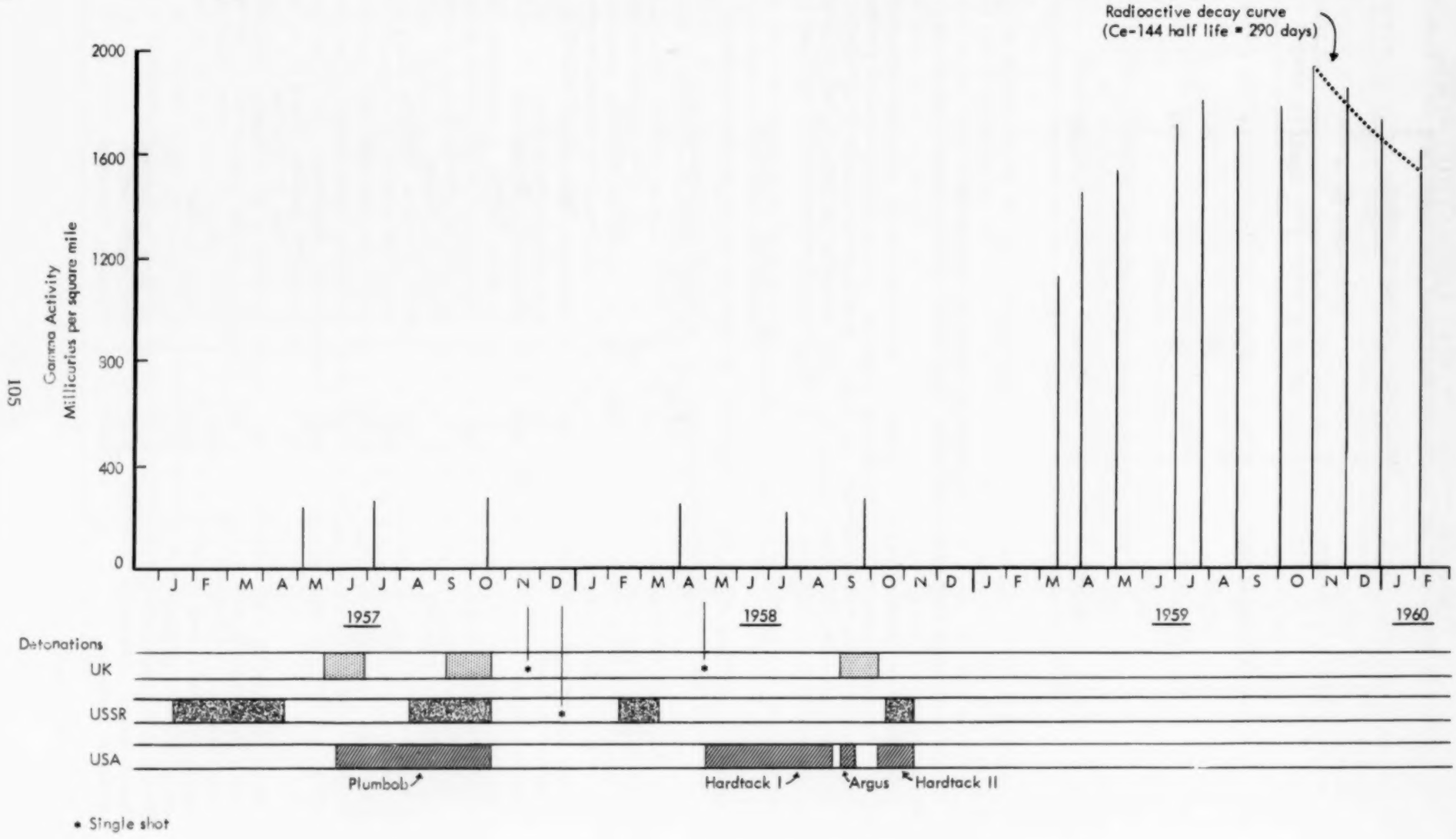


TABLE XXI.—FISSION PRODUCT RADIOACTIVITY IN SOIL AT ARGONNE NATIONAL LABORATORY

(Millicuries per square mile)

Isotopes	Collection dates	
	March 2, 1960	April 11, 1960
Zr^{95}-Nb^{95}	112	90
Cs^{137}	195	197
Rw^{106}	950	915
Ru^{103}	-	-
Ce^{141}	-	-
Ce^{144}	1,610	1,650

EXTERNAL GAMMA ACTIVITY
PUBLIC HEALTH SERVICE RADIATION SURVEILLANCE NETWORK

Portable survey instruments are available at the stations of the Radiation Surveillance Network and one of their uses is to record external gamma radiation. These readings are not precise, especially for measurement of low levels but they can show the presence or absence of any significant increases above background. The differences among the values shown on the following table are within the variances anticipated due to differences in normal background and in instrument response characteristics.

TABLE XXII.—EXTERNAL GAMMA ACTIVITY

PUBLIC HEALTH SERVICE RADIATION SURVEILLANCE NETWORK

Milliroentgens per hour—at three feet above the ground
For month of February 1960

Station location	Average	Station location	Average
Alaska, Anchorage	0.01	Minnesota, Minneapolis	0.01
Alaska, Fairbanks	0.01	Mississippi, Pascagoula	(*)
Alaska, Juneau	0.02	Missouri, Jefferson City	0.01
Arizona, Phoenix	0.01	Montana, Helena	0.02
Arkansas, Little Rock	0.02	New Jersey, Trenton	0.02
California, Berkeley	(*)	New Mexico, Santa Fe	0.04
California, Los Angeles	0.01	New York, Albany	0.02
Colorado, Denver	0.02	North Carolina, Gastonia	0.02
Connecticut, Hartford	0.01	Ohio, Cincinnati	(*)
District of Columbia	0.02	Oklahoma, Oklahoma City	0.02
Florida, Jacksonville	0.02	Oklahoma, Ponca City	0.04
Georgia, Atlanta	0,02	Oregon, Portland	0.02
Hawaii, Honolulu	0.02	Pennsylvania, Harrisburg	(*)
Idaho, Boise	(*)	Rhode Island, Providence	0.02
Illinois, Springfield	(*)	South Carolina, Columbia	0.02
Indiana, Indianapolis	0.01	South Dakota, Pierre	0.02
Iowa, Iowa City	0.01	Texas, Austin	0.02
Kansas, Topeka	0.02	Texas, El Paso	0.02
Louisiana, New Orleans	0.02	Utah, Salt Lake City	0.02
Maryland, Baltimore	0.02	Virginia, Richmond	0.01
Massachusetts, Lawrence	0.02	Washington, Seattle	0.02
Michigan, Lansing	0.02	Wyoming, Cheyenne	0.02

*No data received.

ENVIRONMENTAL RADIOACTIVITY—SHIPPINGPORT ATOMIC POWER STATION

The first commercial atomic power reactor to go into operation in the United States was at Shippingport, Pennsylvania. On June 1, 1960, the U. S. Atomic Energy Commission through its Pittsburgh Naval Reactors Operations Office, issued its report on environmental radioactivity for the calendar year 1959. Believing that this report on environmental radioactivity associated with the first commercial atomic power reactor will be of general interest, it is reproduced below.

SUMMARY OF ENVIRONMENTAL RADIOACTIVITY AT THE SHIPPINGPORT ATOMIC POWER STATION

For Calendar Year 1959

PNROO-DEV-100

Report to Pennsylvania Department of Health
By U. S. Atomic Energy Commission
Pittsburgh Naval Reactors Operations Office, Pittsburgh, Pa.

June 1, 1960

The Shippingport Atomic Power Station is the world's first large scale nuclear power electrical generating station and is operated for the Atomic Energy Commission by the Duquesne Light Company. For two years prior to the plant's initial operation in December, 1957, an environmental radiation survey was conducted in the Shippingport area by the Atomic Energy Commission in order to establish reliable data on radiation levels in the area prior to plant completion. This program has been continued during the operation of the station. To limit the amounts of radioactivity reaching the surrounding areas, stringent controls on reactor operation are maintained at all times in addition to the safety features that have been designed into the plant. The environmental radiation survey serves as a check on plant operation and has thus far indicated that controls and design features have been completely adequate to minimize radioactivity released to the environment.

During 1959, the plant operated at various power levels for nearly 3,500 hours and produced over 201 million kilowatt-hours gross electrical energy.

The liquid and gaseous discharge from Shippingport are controlled so that concentrations of radioactivity added by the plant to background radioactivity levels do not exceed those recommended by the National Committee on Radiation Protection (NCRP). The criteria established by this Committee are considered to be the best available and have been adopted by such groups as the AEC, U. S. Public Health Service and the Pennsylvania Department of Health. In addition, the Duquesne Light Company as operator of Shippingport, has a permit granted by the State of Pennsylvania to discharge limited amounts of liquid radioactive wastes to the Ohio River. These limits are such to insure that permissible concentrations as established by the NCRP and Pennsylvania Regulation 433 are not exceeded.

LIQUID RADIOACTIVE WASTE DISPOSAL

The limits for discharge of radioactive wastes at Shippingport are based on criteria which depend on a knowledge of the radioactive materials which make up the waste. If the quantity of a particular radioactive species is known, the discharge of that particular species may be based on the limit for that individual material. If the quantities of specific radioactive isotopes are not identified, then a more stringent limit for gross unknown mixtures of radioactive material is used. At Shippingport, most of the wastes are discharged according to the limit for gross unidentified mixtures of radioactivity. This is now done because the total quantity of radioactivity in the waste is low and analysis for many specific radioactive isotopes is laborious and expensive. However, the discharge of a known lower hazard radioactive isotope called tritium is controlled separately based on its own limit since its formation in the reactor plant can be predicted with relative ease.

The waste discharge criteria for the plant impose the restriction that radioactivity released to the environment does not increase the background radioactivity levels by more than 10 percent of the permissible concentrations recommended by the NCRP. This factor of 10 to the NCRP recommended permissible concentrations is usually applied for areas outside an atomic energy installation. At Shippingport this criterion is applied to the actual plant discharges and no allowance is made for the dilution available in the environment except for that river water actually pumped through the plant for cooling the condensers.

The following table shows the average total daily discharges of gross radioactivity to the Ohio River during 1959:

	Gross radioactivity average total daily discharge, μc/day*
First quarter	97.2
Second quarter	73.4
Third quarter	192.2
Fourth quarter	536.4

*Microcuries per day.

Maximum discharge in one day was 3,712.8 microcuries.

The average total daily allowable discharge of unidentified mixtures of radioactivity according to the Pennsylvania waste permit is 1,590 microcuries per day. The maximum total daily allowable discharge according to the Pennsylvania waste permit is 6,200 microcuries in any one day.

The average total daily discharges of the lower hazard radioactive isotope tritium during 1959 were as follows:

	Average daily total discharge of tritium, curies per day
First quarter	0.18
Second quarter	0.21
Third quarter	0.19
Fourth quarter	0.11

Maximum discharge in any one day was 3.6 curies.

The average total discharge of tritium allowed per day under the Pennsylvania waste permit is 10 curies. The maximum total discharge of tritium allowed in any one day under the Pennsylvania waste permit is 50 curies.

Average concentrations of Shippingport radioactive waste discharges to the Ohio River during 1959 are summarized below. These averages were computed using the measured total quantities of radioactivity, the known amount of dilution water from the plant, and the known waste discharge time periods. These average concentrations are in addition to the background radioactivity in the river water pumped through the turbine-generator plant condenser for cooling purposes, and also used for dilution of the radioactive liquid wastes.

	Average concentration of gross radioactivity in effluent channel μc/cc*	Average concentration of tritium in effluent channel μc/cc*
First quarter	1.7×10^{-9}	2.1×10^{-5}
Second quarter	1.4×10^{-9}	2.1×10^{-5}
Third quarter	2.8×10^{-9}	0.85×10^{-5}
Fourth quarter	5.2×10^{-9}	0.52×10^{-5}

*Microcuries per cubic centimeter.

The maximum concentration of gross radioactivity at any one time during the year was 1.2×10^{-8} μc/cc. This concentration was discharged for 1 1/2 hours on December 16, 1959. All other discharges during 1959 were less than 1×10^{-8} μc/cc. The minimum concentration of gross radioactivity during a waste discharge was 1×10^{-11} μc/cc which occurred several times during the year.

The criterion for continuous discharge of unidentified mixtures of radioactive materials from Shippingport to the Ohio River is 1×10^{-8} μc/cc. This is one-tenth of the permissible concentration for unknown mixtures of radioisotopes in drinking water as recommended by the National Committee on Radiation Protection (NCRP) for lifetime consumption. One-tenth of the permissible concentration for tritium recommended by the NCRP is 3×10^{-3} μc/cc.

The liquid radioactive wastes from Shippingport during 1959 have not shown a detectable effect on the background radioactivity level of Ohio River water. The average concentration of gross radioactivity added to the effluent leaving the plant was appreciably lower than both the permissible con-

centration and the background river water radioactivity level upstream. Variations in background river radioactivity levels are attributed to normal statistical variation and changes in meteorological conditions affecting river flow. Tritium discharges were also considerably below the permissible concentration for that radioactive isotope.

Weekly composite river water samples are routinely collected at locations upstream and downstream from the waste disposal system effluent and are analyzed for gross radioactivity. The results of measurements made during 1959 are shown in the following table:

1959	Average upstream measured gross radioactivity in μc/cc*	Average downstream measured gross radioactivity in μc/cc*
First quarter.....	3.6×10^{-8}	4.8×10^{-8}
Second quarter.....	2.4×10^{-8}	2.5×10^{-8}
Third quarter.....	1.1×10^{-8}	1.6×10^{-8}
Fourth quarter.....	2.0×10^{-8}	1.9×10^{-8}

*Microcuries per cubic centimeter.

The maximum upstream gross radioactivity detected during 1959 was 9.1×10^{-8} μc/cc (microcuries per cubic centimeter) while the minimum was 9.0×10^{-10} μc/cc.

The maximum downstream gross radioactivity detected during 1959 was 1.2×10^{-7} μc/cc while the minimum was 2.9×10^{-9} μc/cc.

Radioactive waste discharges from the plant increased somewhat during the latter part of 1959 as compared with the first part, whereas Ohio River water background radioactivity levels decreased during the same period.

RELEASE OF RADIOACTIVE WASTES TO THE ATMOSPHERE

During 1959, some gaseous radioactivity was released to the atmosphere from the waste disposal system. The quantity released was less than one percent of plant design. In January, the only time gas was released, a total of 13,927 microcuries composed primarily of radioactive krypton-85 was discharged at a controlled rate over a period of 102 1/2 hours. This gaseous waste had an average concentration of 8.9×10^{-8} μc/cc of air at the stack exit during release. This was considerably less than 3×10^{-7} μc/cc which is one-tenth the permissible concentration for krypton-85 in air recommended by the National Committee on Radiation Protection for continuous life time breathing.

An incinerator for burning contaminated combustible material is located in the waste disposal plant and is generally used several times a month. The exhaust from the incinerator passes through a wet gas scrubber and a filter before entering the stack to remove any particulate radioactivity. The exhaust is monitored at the stack exit to record the level of radioactivity leaving the plant. During 1959 the maximum radioactivity monitored at the stack exit during incinerator operation was 8.7×10^{-11} uc/cc of air and the minimum was 2.4×10^{-13} uc/cc of air. These concentrations were less than the permissible concentration for such airborne particulates of 1×10^{-10} uc/cc as recommended by NCRP.

AREA MONITORING

During the Calendar Year 1959 five monitoring stations were used continuously to monitor and record background levels of beta-gamma radiation and levels of airborne particulate radioactivity in the vicinity of the Shippingport site. The data recorded by each station during this period was checked and tabulated weekly.

One of the stations is located on the Shippingport site and three are located to the north, east and south about one-half mile from the site. The locations were selected because of prevailing wind conditions. The fifth station was moved periodically to different locations.

Much of the 1959 data listed in the following table are comparable to data collected during the pre-operational survey of the Shippingport site. With the exception of one mobile station the monitoring stations were in the same locations during the pre-operational survey as they were during the Calendar Year 1959.

AVERAGE BETA-GAMMA BACKGROUND RADIATION LEVELS–1959

MILLIROENTGENS PER HOUR (MR/HR)

1959	
First quarter	0.019
Second quarter	0.023
Third quarter	0.019
Fourth quarter	0.012
Average for the year	0.018 mr/hr.
Maximum recorded during the year	0.059 mr/hr. (average for a one-week period)
Minimum recorded during the year	0.005 mr/hr. (average for a one-week period)
Average for pre-operational radiation survey (1956-57).	0.016 mr/hr.

A survey made by the United States Atomic Energy Commission throughout the United States in 1957 showed that background radiation intensities in various parts of the United States varied from 0.038 milliroentgen per hour (mr/hr) to 0.028 mr/hr. Data presented in the above table indicate that the average background radiation levels in the vicinity of the Shippingport Site are well within the national range measured in 1957.

CONTINUOUS MONITORING OF AIRBORNE PARTICULATE RADIOACTIVITY

A continuous air monitor in each of the monitoring stations is used to monitor and record levels of airborne particulate radioactivity. As indicated in the following table, the average concentration of particulate radioactivity of the air in the vicinity of the Shippingport Site for 1959 is well below the maximum permissible concentration established on the basis of recommendations by the National Committee on Radiation Protection. A comparison of the airborne activity data taken in 1959 to that taken during the pre-operational survey indicates no appreciable difference in levels of airborne particulate radioactivity.

1959	Average concentration of airborne particulate radioactivity $\mu c/cc$*
First quarter	1.0×10^{-12}
Second quarter	1.4×10^{-12}
Third quarter	2.3×10^{-12}
Fourth quarter	1.7×10^{-12}
Average airborne concentration for 1959	1.5×10^{-12} $\mu c/cc$
Maximum airborne concentration detected during the year.	7.8×10^{-12} $\mu c/cc$
Minimum airborne concentration detected during the year.	7.8×10^{-14} $\mu c/cc$
Average airborne concentration during pre-operational survey (1956-57).	2.1×10^{-12} $\mu c/cc$
Maximum permissible concentration**	1.0×10^{-10} $\mu c/cc$

*Microcuries per cubic centimeter of air.

**The maximum permissible concentration for air established on basis of NCRP recommendations (NBS Handbook 69).

FALLOUT

Trays to collect fallout from the atmosphere are placed at each of the five area monitoring stations. Each tray is equipped with a special gummed paper on which the fallout is collected. The

samples are collected and analyzed weekly for gross beta radioactivity. The results of this sampling program for 1959 are presented in the following table:

Average Beta Radioactivity in Fallout

Expressed in $mc/mi^2/mo.$*

	STATIONS	
1959	2-3-5 upwind	1-4 downwind
First quarter	298	308
Second quarter	198	227
Third quarter	19.3	24.6
Fourth quarter	9.5	6.1
Maximum concentration upwind		374 $mc/mi^2/mo.$
Minimum concentration upwind		1.9 $mc/mi^2/mo.$
Maximum concentration downwind		420 $mc/mi^2/mo.$
Minimum concentration		2.2 $mc/mi^2/mo.$

*Millicuries per square mile per month.

The predominant wind direction in the vicinity of the Shippingport site is from West to East. The above data indicate that there is no significant difference between the fallout values upwind and downwind and that the contribution to fallout by the Shippingport operation is negligible.

SOIL SAMPLING

Soil samples are collected quarterly from twenty locations within a radius of approximately five miles of the Shippingport site. A comparison of the data taken in 1959 with that data taken during the pre-operational survey shows no significant increase in concentrations.

1959	Average concentration of alpha activity in soil samples in $\mu c/gram$*	Average concentration of beta activity in soil samples in $\mu c/gram$*
First quarter	1.72×10^{-5}	1.77×10^{-5}
Second quarter	1.85×10^{-5}	2.06×10^{-5}
Third quarter	1.88×10^{-5}	1.68×10^{-5}
Fourth quarter	1.55×10^{-5}	1.69×10^{-5}
Average alpha concentration for 1959		1.75×10^{-5} $\mu c/gram$
Average beta concentration for 1959		1.80×10^{-5} $\mu c/gram$
Maximum alpha concentration for 1959		3.34×10^{-5} $\mu c/gram$
Minimum alpha concentration for 1959		8.1×10^{-6} $\mu c/gram$
Maximum beta concentration for 1959		3.79×10^{-5} $\mu c/gram$
Minimum beta concentration for 1959		0.96×10^{-5} $\mu c/gram$
Average alpha concentration during pre-operational survey (1956-57)		1.54×10^{-5} $\mu c/gram$
Average beta concentration during pre-operational survey (1956-57)		1.58×10^{-5} $\mu c/gram$

*Microcuries per gram of soil.

SUMMARY

Measurements of radioactivity in the air, river water, soil and fallout in the Shippingport environment show that the Shippingport Atomic Power Station did not contribute significant quantities of radioactivity to the surrounding areas.

During 1959 the average concentration of gross radioactivity in the liquid effluent was 2.8×10^{-9} μc/cc in addition to background radioactivity while the average concentration of tritium discharged was 1.4×10^{-5} μc/cc. Both of these values are within the standards for drinking water established by the National Committee on Radiation Protection and Pennsylvania Regulation 433. The average concentration of gross radioactivity in the Ohio River varied between 1.1×10^{-8} to 3.6×10^{-8} μc/cc in samples collected upstream from the plant and from 1.6×10^{-8} to 4.8×10^{-8} μc/cc downstream. The apparent higher downstream levels cannot be attributed to waste discharges from Shippingport because the radioactivity levels in the river were lowest at the times when the quantity of wastes released was highest. A review of the concentrations in the effluent during discharge confirms this. The differences are believed to be due to normal statistical variation often found in low level radioactivity monitoring of this type.

Release of radioactive material to the atmosphere was minimal during 1959 as can be ascertained from a review of the monitoring results of gaseous waste disposal discharges and incinerator operation. Continuous monitoring of airborne particulate radioactivity in the atmosphere of the area indicated an average concentration of 1.5×10^{-12} μc/cc for 1959. This value is within the maximum permissible concentration of 1×10^{-10} μc/cc recommended by NCRP for unidentified radioactive materials in air. The average beta-gamma background radiation level for the Shippingport area in 1959 was 0.018 milliroentgens per hour. This is within the background ranges measured in the U. S. in 1957 by the AEC.

Measurements of the concentrations of radioactivity in soil samples showed little change when compared with similar data obtained during similar surveys made prior to plant operation. No significant contribution to either soil radioactivity levels or radioactive fallout levels from Shippingport was evident during 1959. Fallout values obtained generally downwind from the plant did not vary significantly from those obtained upwind which indicated no contribution to fallout levels from Shippingport. Measurements of fallout showed a general decrease in levels during the year.

62597--U.S.Dept.of Comm--DC--1960